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

(11) EP 2 843 127 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.03.2015 Bulletin 2015/10

(21) Application number: **14155344.6**

(22) Date of filing: **17.02.2014**

(51) Int Cl.:
D06P 5/20 *(2006.01)*
D06M 23/10 *(2006.01)*
D06P 1/00 *(2006.01)*
D06B 19/00 *(2006.01)*
B08B 7/00 *(2006.01)*
D06P 1/94 *(2006.01)*
D06L 1/00 *(2006.01)*
C11D 11/00 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **26.08.2013 CN 201310375961**

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(54) Method of waterless processing of textile materials using supercritical fluid

(57) The present application is directed to a method of waterless processing of textile materials using supercritical fluid, including the use of supercritical fluid to dye the textile materials, the use of supercritical fluid for a pre-processing procedure of cleansing the textile materials, and the use of supercritical fluid to wash off unfixed dyes and cleansing of the textile materials and to perform the post-processing procedure of adding functional materials after the use of supercritical fluid to dye the textile materials. The present application provides an integrated technology of pre-processing, dyeing and post-processing of textile materials using supercritical fluid. At the same time, cleansing and dyeing are performed which effectively raises the efficiency.

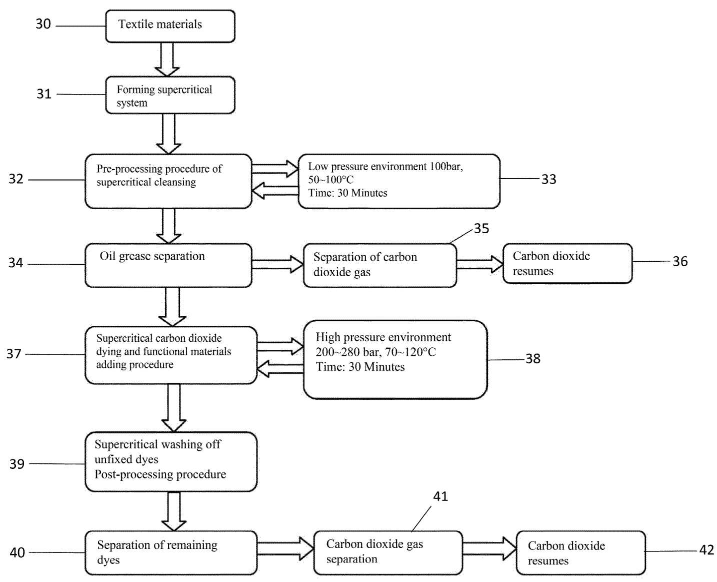

FIG. 3

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Description

FIELD OF THE TECHNOLOGY

[0001] The present application is directed to a waterless processing of textile materials using supercritical fluid.

BACKGROUND

[0002] Traditional process of the processing and dyeing of textiles mainly applies water as the medium. Besides consuming large amount of water resource, it creates problems to the environment such as water contamination, high energy consumption and high processing fee. Concurrently, many countries and regions are placing restrictions on environmental law, leading to dilemmas faced by the long-established dyeing processing industry. In order to solve the problem of water contamination brought about by the textile dyeing and processing industry, the Hong Kong Productivity Council commenced the development of supercritical carbon dioxide waterless dyeing technology in 2005, which utilizes the recycled carbon dioxide emitted by industries as the carrier and carry the dyes onto the textiles to be dyed in a supercritical state. The feature of this technology is that this dyeing procedure does not apply water, the dyes and the carbon dioxide can be recycled and the dyeing procedure does not require the use of chemical additives. Hence, it completely solved the problem of water contamination in the traditional textile dyeing and processing industry. The supercritical carbon dioxide is a superb non-polar solvent, which can dissolve oil grease, oily material and impurities on some functional materials or textiles. Therefore, besides the dyeing procedure, such technology can be applied during the pre-processing of textiles for extracting oil grease and impurities. For example, at the time of cleansing and rinsing, functional materials, such as silicon or fluorine-type of synthetic material with water-proof function, can be added in the dyeing procedure. So the dyeing and functional processing procedure under waterless processing can be performed simultaneously, and the total processing time can be reduced.

[0003] In recent research projects, such as that in Hong Kong short term patent application no. 06112486.0, dyeing with supercritical carbon dioxide has already been proven for being able to be widely utilized in the dyeing of synthetic fibers. However, it lacks the specific work flow towards the processing of the textile materials before and after the dyeing. Since in actual dyeing production, the pre-processing and post-processing of dyeing are also very important steps. The creation of a waterless dyeing technique with the application of supercritical carbon dioxide in the pre-processing and post-processing of dyeing is necessary to satisfy the dyeing and processing industry.

SUMMARY

[0004] The technical problem that the present application seeks to solve is to provide a method of waterless processing of textile materials using supercritical fluid. It is a completely waterless and environmental-friendly textile processing procedure, which can complete the pre-processing of cleansing (such as the procedure of removing grease and impurities), functional processing, independent processing or continuous processing of the dyeing procedure and post-processing and cleansing of washing off unfixed dyes in textile materials as such procedures.

[0005] The present application provides the use of supercritical liquid to perform highly efficient pre-processing, dyeing and post-processing of textile materials as an integration technology, which can clean and dye at the same time and highly raise the efficiency level. The cleansing procedure can be proceeded as a continuous direct cleansing procedure, which is different from the traditional indirect cleansing in batches. It can greatly raise the cleansing efficiency and reduce the cleansing time. The present application is suitable for performing pre-processing of cleansing, dyeing, post-processing of washing off unfixed dyes or adding functional materials to artificial or natural textile materials. It can supersede traditional processing procedure of the pre-processing of scouring, dyeing and post-processing and adding functional materials.

[0006] According to one aspect, there is provided a method of waterless processing of textile materials using supercritical fluid. The method includes a pre-processing procedure of cleansing a textile material using a supercritical fluid, before a process of dyeing the textile material using the supercritical fluid. The method may further include a post-processing procedure of washing off unfixed dyes on the textile material using the supercritical fluid, after the process of dyeing the textile material using the supercritical fluid. The method may further include a post-processing procedure of adding a functional material to the textile material using the supercritical fluid, after the process of dyeing the textile material using the supercritical fluid.

[0007] In one embodiment, the pre-processing procedure of cleansing may include treating gaseous carbon dioxide by a supercritical process so that the gaseous carbon dioxide reaches a supercritical state; passing the supercritical carbon dioxide through a high-pressure cauldron with the textile material provided therein, thereby rinsing the textile material and removing grease therefrom; and depressurizing and separating the grease from the carbon dioxide, and collecting the carbon dioxide in gaseous state for re-use.

[0008] In one embodiment, the post-processing procedure of washing off unfixed dyes may include treating gaseous carbon dioxide by a supercritical process so that the gaseous carbon dioxide reaches a supercritical state; passing the supercritical carbon dioxide through a high-pressure cauldron with the textile material provided therein, thereby washing the textile material and removing the unfixed dyes therefrom; and depressurizing and separating the unfixed dyes from the carbon dioxide, and collecting the carbon dioxide in gaseous state for re-use.

[0009] The method may further include the step of adding an organic solvent in the high-pressure cauldron in advance in the pre-processing procedure of cleansing and the post-processing procedure of washing off unfixed dyes, wherein the added organic solvent is in an amount of 0.1-10% by weight of the textile material.

[0010] In one embodiment, the post-processing procedure of adding the functional material may include treating gaseous carbon dioxide by a supercritical process so that the gaseous carbon dioxide reaches a supercritical state; passing the supercritical carbon dioxide into a functional material can with the functional material provided therein so that the functional material is dissolved in the supercritical carbon dioxide; passing the supercritical carbon dioxide with the dissolved functional material into a high-pressure cauldron with the textile material provided therein, thereby performing sedimentation of the functional material in the textile material; and depressurizing and separating the functional material from the carbon dioxide, and collecting the carbon dioxide in gaseous state for re-use. During the procedure of sedimentation of the functional material, the supercritical carbon dioxide with the dissolved functional material in the high-pressure cauldron may be led back to an entry port of the functional material can through a control valve, a flow meter and a high-pressure cycling pump, thereby repeatedly performing sedimentation of the functional material until the functional material is fully absorbed by the textile material.

[0011] The method may further include the step of adding a functional material into a dyeing can containing a dyeing material, passing supercritical carbon dioxide into the dyeing can so that it dissolves the dyeing material and the functional material; and passing the supercritical carbon dioxide with the dissolved dyeing material and functional material into a high-pressure cauldron with the textile material provided therein, thereby performing sedimentation of the dyeing material and the functional material in the textile material. The functional material can be a compound comprising fluorine or silicon.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Figure 1 is an illustrative diagram of a pre-processing cleansing procedure according to an embodiment of the present application;

Figure 2 is an illustrative diagram of a dyeing and functional material adding procedure according to an embodiment of the present application;

Figure 3 is a flow chart of the cleansing, dyeing, washing off unfixed dyes procedures according to an embodiment of the present application.

DETAILED DESCRIPTION

[0013] Below is a further description of the present application in combination with drawings and specific embodiments for allowing the skilled in the art to have a better understanding on the present application for execution. However, the disclosed embodiments do not serve as limitations of the present application.

Figure 1 is an illustrative diagram of a pre-processing cleansing procedure according to an embodiment of the present application. The present application provides a method of waterless processing of textile materials using supercritical fluid, including the pre-processing procedure of cleansing the textile materials using supercritical fluid before the process of dyeing of the textile materials using supercritical fluid. An embodiment of the procedure of the cleansing process is illustrated in Figure 1 and is described as follows:

Step 1: Carbon dioxide in a carbon dioxide storage can 1 can be cooled to a temperature at about 0~10°C (preferably at 5°C) by a first cooler 2. At this time, the carbon dioxide is in liquid form. It is then pressurized by a carbon dioxide pressurizing pump 3, causing the pressure to reach about 8~10Mpa. Thereafter, the temperature can be raised to about 50~100°C by a heat exchanger 4, causing the carbon dioxide to reach a supercritical state. An upper part of the carbon dioxide storage can 1 may be provided with a pressure meter 12.

Step 2: The carbon dioxide in the supercritical state can be passed into a high-pressure cauldron 5 to rinse textile materials 6 inside the high-pressure cauldron 5. An upper part of the high-pressure cauldron 5 may be provided with a pressure meter 7. Through the rinsing of the textile materials by the supercritical carbon dioxide, grease on the textile materials can be removed from the textile materials and dissolved in the supercritical carbon dioxide. The rinsing time may be about 20~50 minutes (e.g. 30 minutes) and can be specifically determined according to the textile materials to be cleansed. A small amount of an organic solvent such as acetone, isopropanol and methanol etc. can be added in advance in the high-pressure cauldron 5. The added organic solvent can be in an amount of about 0.1-10% (preferably at 0.5%) by weight of the textile materials. This can effectively increase the cleansing efficiency and reduce the cleansing time.

Step 3: The supercritical carbon dioxide carrying the grease after rinsing can be depressurized by a depressurizing valve 8, causing the pressure to be reduced to about 4~7Mpa. The heat that is required to be absorbed in the process can be replenished by a heat exchanger 9, causing the temperature in the process to be maintained at about 40~60°C. The depressurized process would cause the carbon dioxide in the supercritical state to be converted to gaseous carbon dioxide. The gaseous carbon dioxide after being depressurized can be passed into a carbon dioxide separating can 10. In particular, the dissolved grease can be released and present in liquid or solid form, and kept at the bottom of the carbon dioxide separating can 10. The gaseous carbon dioxide at an upper layer of the carbon dioxide separating can 10 would be released and enter into a second cooler 11, causing the temperature to be dropped and maintained at about 0~10°C (preferably at 5°C). Only at this time the carbon dioxide can be converted to liquid form and recycled to the carbon dioxide storage can 1 for second round cleansing. This forms a continuous cleansing procedure using supercritical fluid.

[0014] An embodiment of the post-processing of washing and adding of functional material of the textile material using supercritical fluid is illustrated in Figures 2 and 3, and is described as follows:

Step 1: Carbon dioxide in a carbon dioxide storage can 13 can be dropped and maintained at a temperature of about 0~10°C (preferably at 5°C) by a third cooler 14. At this time, the carbon dioxide is in liquid form. In a supercritical process, the carbon dioxide in liquid form can be pressurized by a carbon dioxide pressurizing pump 15, causing the pressure to reach 20~28Mpa. At this stage, the carbon dioxide reaches a supercritical state. Then, the temperature can be raised to about 70~120°C by a heat exchanger 16. A top part of the carbon dioxide storage can 13 may be provided with a pressure meter 28.

Step 2: The supercritical carbon dioxide may enter a dyeing can 17. The dyeing can 17 may be provided therein with dyeing material and functional material. The functional material can be silicon-type of oily compound or fluorine-type of oily compound, such as hexafluoroethane, perfluorohexane, dimethyl chlorosilane or silicon tetrachloride etc, which can cause the textile materials to possess water resistant capability. The added dying material and functional material may be in an amount of 0.5~5% (preferably at 1%) by weight of the textile materials. This can cause the supercritical carbon dioxide to dissolve the dyeing material and the functional material. These materials may then be passed into a high-pressure cauldron 18. Textile materials 19 are then dyed and the functional material can be absorbed by the textile materials in the high-pressure cauldron 18. An upper part of the high-pressure cauldron 18 can be provided with a pressure meter 20. During the process, the carbon dioxide with the dissolved dyeing material and functional material can be led back to the dyeing can 17 through a back flow control valve 21, a flow meter 22 and a high-pressure cycling pump 23, to thereby repeatedly perform dyeing and absorbing of the functional material until the dyeing material and functional material are fully absorbed by the textile materials. In particular, a top part of the high-pressure cauldron 18 can be connected with the back flow control valve 21. The back flow control valve 21 may be connected to an entry port of the dyeing can 17 through the flow meter 22 and the high-pressure cycling pump 23, resulting in a circulating flow path. The duration of the whole dyeing process may be about 20~50 minutes, e.g. 30 minutes, and can be lengthened or shortened according to actual need.

Step 3: After the dyes and functional materials have been absorbed, a depressurizing valve 24 connected to a top part of the high-pressure cauldron 18 can depressurize the carbon dioxide with the dissolved dyeing material and functional material to about 4~6Mpa (preferably at 5Mpa). At this time, the heat absorbed can be replenished by a heat exchanger 25, causing the temperature to be maintained at about 40~60°C, and further causing the carbon dioxide with the dissolved dyeing material and functional material in the high-pressure cauldron 18 to enter a carbon dioxide separating can 26 through the depressurizing valve 24 and heat exchanger 25. At this time, the carbon dioxide is in gaseous form. The remaining dyeing and functional materials in the carbon dioxide separating can 26 can be released in solid form or liquid form and kept at the bottom of the carbon dioxide separating can 26. The gaseous carbon dioxide can be released from an upper layer of the carbon dioxide separating can 26 and can then enter a forth cooler 27, causing the temperature to drop to about 0~10°C (preferably at 5°C). Only at this time the carbon dioxide can be converted to liquid form and be recycled to the carbon dioxide storage can 13 for re-use.

[0015] The present application provides a method of waterless processing of textile materials using supercritical fluid, and also includes a procedure of independently adding the functional materials after dyeing. Firstly, a preprocessing procedure of cleansing can be performed on the textile materials using supercritical fluid. Secondly, the supercritical fluid can be used for dyeing of and adding functional materials to the textile materials. Lastly, a post-processing procedure of washing off unfixed dyes can be performed on the textile materials using supercritical fluid. The detailed work flow is illustrated in Figure 3.

[0016] Firstly, the pre-processing procedure of cleansing is as follows:

> After textile materials 30 are placed in a high-pressure cauldron, the temperature of carbon dioxide can first be dropped and maintained at about 0~10°C (preferably at 5°C) by a cooler. The carbon dioxide is in liquid form, and can be pressurized to a supercritical state by a carbon dioxide pressurizing pump 31. During the cleansing process 32, the pressure can be controlled at about 8~10Mpa, and the temperature can be raised to about 50~100°C by a heat exchanger 33. After entering into the high-pressure cauldron, the textile materials provided therein can be rinsed. Upon rinsing, the carbon dioxide carrying the grease can be depressurized to about 4~6Mpa by a depressurizing valve, and the temperature can be maintained at about 40~60°C. It then enters a carbon dioxide separating can. At this time, the carbon dioxide is in gaseous form. The grease can be released in liquid form or solid form and kept at the bottom of the carbon dioxide separating can 34. The gaseous carbon dioxide can be released from an upper portion of the carbon dioxide separating can and can then enter a cooler, causing the temperature to be dropped and maintained at a temperature of about 0~10°C (preferably at 5°C) 35. Only at this time the carbon dioxide can be converted to liquid form and be recycled by a carbon dioxide storage can for a second round cleansing 36. This forms a continuous cleansing procedure using supercritical fluid.

[0017] Secondly, the procedure of dyeing and adding functional material is as follows:

> After cleansing, the procedure of dyeing and adding of functional materials may begin 37. The pressure can be maintained at about 20~30Mpa and the temperature can be raised to about 70~120°C 38. The textile materials may then enter a dyeing can in which dyeing material and functional material are added. During the process, the carbon dioxide with the dissolved dyeing material and functional material can repeatedly perform dyeing and adding of functional materials in the high-pressure cauldron through the use of a flow meter and a high-pressure cycling pump, until the dyeing material and the functional material are fully absorbed by the textile materials. Through a depressurizing valve, the pressure can be lowered to about 4~6Mpa, and the temperature can be maintained at about 40~60°C. The carbon dioxide can enter into a carbon dioxide separating can. At this time, the carbon dioxide is in gaseous form. The remaining dyeing and functional materials can be released in solid or liquid form and kept at the bottom of the carbon dioxide separating can. The gaseous carbon dioxide can be released from an upper portion of the carbon dioxide separating can and can then enter into a cooler, causing the temperature to be dropped and maintained at about 0~10°C (preferably at 5°C). Only at this time, the carbon dioxide is in liquid form and can be recycled by the carbon dioxide storage can for re-use.

[0018] Repeatedly: the post-processing procedure of washing off unfixed dyes and cleansing is as follows:

> After dyeing and adding of functional material, the procedure of washing off unfixed dyes may begin 39. The pressure of the carbon dioxide in the supercritical state can be maintained at about 7~10Mpa, and the temperature can be raised to 50~100°C by a heat exchanger. The textile materials can enter a high-pressure cauldron and the rinsing of unfixed dyes may begin. After rinsing, the carbon dioxide carrying the unfixed dyes can be depressurized to about 4~6Mpa by a depressurizing valve, causing the temperature to be maintained at about 40~60°C, and can then enter a carbon dioxide separating can. At this time, the carbon dioxide is in gaseous form. The unfixed dyes can be released in liquid or solid form and kept at the bottom of the carbon dioxide separating can 40. The carbon dioxide after separation 41 can be the same as that in the pre-processing procedure of cleansing, and it can be recycled for re-use 42.

Embodiment 1:

[0019] The present embodiment provides a method of processing textile materials using supercritical fluid. Before using the supercritical fluid to dye the textile materials, supercritical fluid can be used in a pre-processing procedure of cleansing the textile materials. A specific procedure is described as follows:

> Liquid carbon dioxide is stored in a storage can with a temperature at moderate level and pressure at about 5Mpa. The carbon dioxide enters into a cooler and the temperature is maintained at about 0~10°C (preferably at 5°C). At this stage, the carbon dioxide is in a fully liquid form. The pressure is maintained at about 5Mpa. During a supercritical process, the carbon dioxide is pressurized to a suitable pressure by a high-pressure pump, and the pressure can be maintained at about 10Mpa to thereby reach a supercritical state. The temperature is raised to 50~100°C by a heat exchanger and the carbon dioxide then enters into a high-pressure cauldron, which rinses textile materials provided therein. The carbon dioxide carrying the grease would be depres-

surized to about 5Mpa by a depressurizing valve. At this time, the heat absorbed can be replenished by a heat exchanger, allowing the temperature to be maintained at about 40°C. The carbon dioxide can then enter into a carbon dioxide separating can. At this time, the carbon dioxide is in gaseous form. The grease dissolved can be released in liquid or solid form and kept at the bottom of the carbon dioxide separating can. The gaseous form carbon dioxide can be released at an upper layer of the carbon dioxide separating can and may then enter a cooler, causing the temperature to be dropped and maintained at about 0~10°C (preferably at 5°C). Only at this time the carbon dioxide can be converted to liquid form and be recycled to the carbon dioxide storage can for second round cleansing. This forms a continuous cleansing procedure using supercritical fluid. The whole procedure takes about half an hour. After cleansing, the textile materials may enter into a dyeing procedure or use for other purposes.

[0020] Embodiment 2 (example of dyeing and adding of functional material):

The present embodiment provides a method of processing textile materials using supercritical fluid. Before using supercritical fluid to dye the textile materials, the supercritical fluid is used in a pre-processing procedure of cleansing the textile materials. The pre-processing procedure of cleansing is exactly the same as that in embodiment 1. A specific procedure of dyeing and adding of functional materials is described as follows:

The liquid carbon dioxide is stored in the storage can at a moderate temperature and pressure at about 5Mpa. The carbon dioxide enters a cooler and the temperature is maintained at about 0~10°C (preferably at 5°C). At this stage, the carbon dioxide is in a fully liquid form. The carbon dioxide can be raised to a suitable pressure by a high-pressure pump, allowing the carbon dioxide to reach a supercritical liquid condition.

The pressure can be maintained at about 28Mpa, and the temperature can be raised to about 70~120°C by a heat exchanger. The carbon dioxide may then enter into a dyeing can, which can be provided therein in advance with dye material and functional material (such as silicon-type or fluorine-type of oily materials). Then it may enter into a high-pressure cauldron and may perform dyeing and adding of functional material to the textile materials. In the dyeing process, the carbon dioxide with the dissolved dyeing material and functional material can repeatedly perform dyeing and adding of functional material through the use of a flow meter and a high-pressure cycling pump, until the dyeing material and the functional material are fully absorbed by the textile materials. The pressure is then lowered to about 5Mpa by a depressurizing valve. At this time, the absorbed heat can be replenished by a heat exchanger, causing the temperature to be maintained at about 40°C. The carbon dioxide may then enter a carbon dioxide separating can which is at this time in gaseous form. The remaining dyeing and functional materials can be released in solid or liquid form and kept at the bottom of the carbon dioxide separating can. The gaseous carbon dioxide may be released from an upper portion of the carbon dioxide separating can, and may enter into a cooler, causing the temperature to be dropped and maintained at about 0~10°C (preferably at 5°C). Only at this time, the carbon dioxide can be converted into liquid form and be recycled through the carbon dioxide storage can for re-use. The whole procedure takes about half an hour. The cleansing pre-processing procedure and dyeing procedure in the present embodiments are performed in order. That is, after completing the cleansing pre-process procedure, the dyeing procedure can be performed under different condition but along the same path. After the dyeing process is completed, the condition can be changed, and can then be followed by a post-processing of washing off unfixed dyes and cleansing. As such, the work flow in this order can effectively raise the efficiency and reduce the operation time.

Embodiment 3:

[0021] The present embodiment provides a method of processing and dyeing textile materials using supercritical fluid, including the post-processing procedure of washing off unfixed dyes after dyeing.

[0022] Liquid carbon dioxide is stored in a storage can with a temperature at moderate level and pressure at about 5Mpa. The carbon dioxide enters a cooler and temperature is maintained at about 0~10°C (preferably at 5°C). At this stage, the carbon dioxide is in a fully liquid form. The carbon dioxide is pressurized to a suitable pressure by a high-pressure pump. The pressure can be maintained at about 10Mpa to reach a supercritical fluid condition. The temperature can then be raised to about 50~100°C by a heat exchanger. The carbon dioxide then enters into a high-pressure cauldron and rinses the textile materials provided therein. The carbon dioxide dissolving the unfixed dyes can be depressurized to about 5Mpa through a depressurizing valve. At this time, the absorbed heat can be replenished by a heat exchanger, causing the temperature to be maintained at about 40°C. The carbon dioxide may then enter into a carbon dioxide separating can. At this time the carbon dioxide is in gaseous form. The dissolved grease and unfixed dyes can be released in liquid form or solid form and kept at the bottom of the carbon dioxide separating can. The gaseous carbon dioxide can be released from an upper portion of the carbon dioxide separating can, and may then flow into a cooler, causing the temperature to be dropped and maintained to about 0~10°C (preferably at 5°C). Only at this time the carbon dioxide can be converted into liquid form, and can be recycled through the carbon dioxide storage can for a second round of cleansing. This forms a continuous cleansing procedure using supercritical fluid.

[0023] The above embodiments are preferred embodiments that merely serve to fully describe the present application. The protection scope of the present application is not limited to them. The skilled in the art can perform equivalent replacement or amendment on the basis of the present application, which shall all fall within the protection scope of the present application. The protection scope of the present application is ultimately determined by the claims.

Claims

1. A method of waterless processing of textile materials using supercritical fluid, the method comprising a pre-processing procedure of cleansing a textile material using a supercritical fluid, before a process of dyeing the textile material using the supercritical fluid.

2. The method of waterless processing of textile materials using supercritical fluid according to claim 1, further comprising a post-processing procedure of washing off unfixed dyes on the textile material using the supercritical fluid, after the process of dyeing the textile material using the supercritical fluid.

3. The method of waterless processing of textile materials using supercritical fluid according to claim 1 or 2, further comprising a post-processing procedure of adding a functional material to the textile material using the supercritical fluid, after the process of dyeing the textile material using the supercritical fluid.

4. The method of waterless processing of textile materials using supercritical fluid according to claim 1, wherein the pre-processing procedure of cleansing comprises:

   treating gaseous carbon dioxide by a supercritical process so that the gaseous carbon dioxide reaches a supercritical state;
   passing the supercritical carbon dioxide through a high-pressure cauldron with the textile material provided therein, thereby rinsing the textile material and removing grease therefrom; and
   depressurizing and separating the grease from the carbon dioxide, and collecting the carbon dioxide in gaseous state for re-use.

5. The method of waterless processing of textile materials using supercritical fluid according to claim 2, wherein the post-processing procedure of washing off unfixed dyes comprises:

   treating gaseous carbon dioxide by a supercritical process so that the gaseous carbon dioxide reaches a supercritical state;
   passing the supercritical carbon dioxide through a high-pressure cauldron with the textile material provided therein, thereby washing the textile material and removing theunfixed dyes therefrom; and
   depressurizing and separating the unfixed dyes from the carbon dioxide, and collecting the carbon dioxide in gaseous state for re-use.

6. The method of waterless processing of textile materials using supercritical fluid according to claim 4 or 5, further comprising the step of adding an organic solvent in
   the high-pressure cauldron in advance in the pre-processing procedure of cleansing and the post-processing procedure of washing off unfixed dyes, wherein the added organic solvent is in an amount of 0.1-10% by weight of the textile material.

7. The method of waterless processing of textile materials using supercritical fluid according to claim 3, wherein the post-processing procedure of adding the functional material comprises:

   treating gaseous carbon dioxide by a supercritical process so that the gaseous carbon dioxide reaches a supercritical state;
   passing the supercritical carbon dioxide into a functional material can with the functional material provided therein so that the functional material is dissolved in the supercritical carbon dioxide;
   passing the supercritical carbon dioxide with the dissolved functional material into a high-pressure cauldron with the textile material provided therein, thereby performing sedimentation of the functional material in the textile material; and
   depressurizing and separating the functional material from the carbon dioxide, and collecting the carbon dioxide in gaseous state for re-use.

8. The method of waterless processing of textile materials using supercritical fluid according to claim 7, wherein during the procedure of sedimentation of the functional material, the supercritical carbon dioxide with the dissolved functional material in the high-pressure cauldron is led back to an entry port of the functional material can through a control valve, a flow meter and a high-pressure cycling pump, thereby repeatedly performing sedimentation of the functional material until the functional material is fully

absorbed by the textile material.

9. The method of waterless processing of textile materials using supercritical fluid according to claim 2, further comprising the step of:

adding a functional material into a dyeing can containing a dyeing material,
passing supercritical carbon dioxide into the dyeing can so that it dissolves the dyeing material and the functional material; and
passing the supercritical carbon dioxide with the dissolved dyeing material and functional material into a high-pressure cauldron with the textile material provided therein, thereby performing sedimentation of the dyeing material and the functional material in the textile material.

10. The method of waterless processing of textile materials using supercritical fluid according to claim 8 or 9, wherein the functional material is a compound comprising fluorine or silicon.

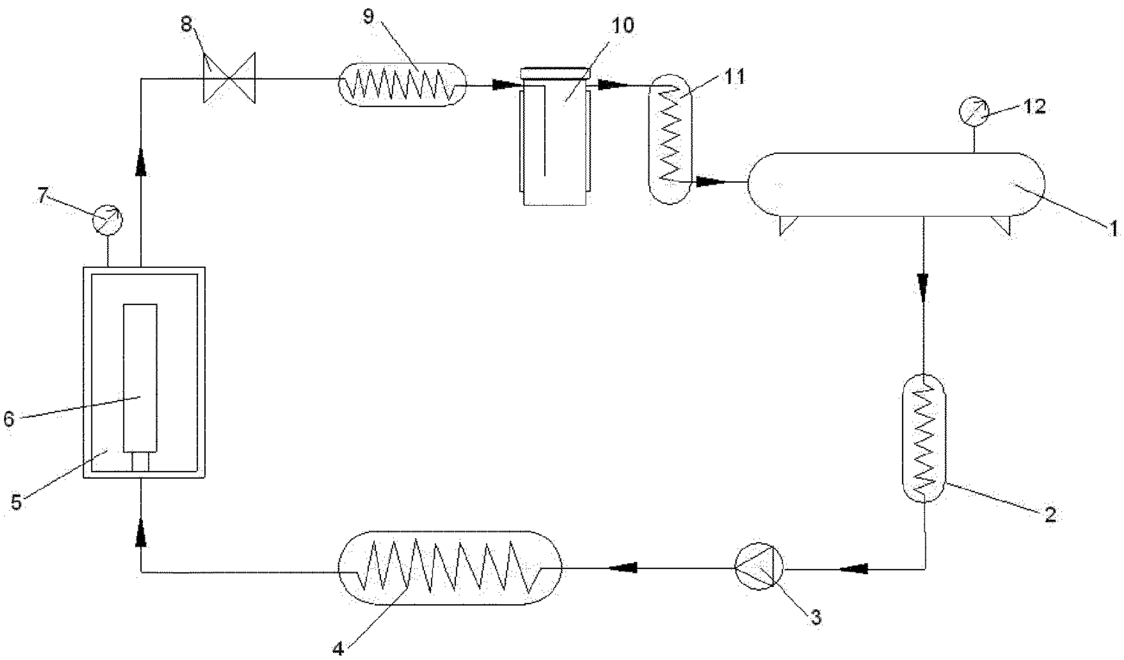

FIG. 1

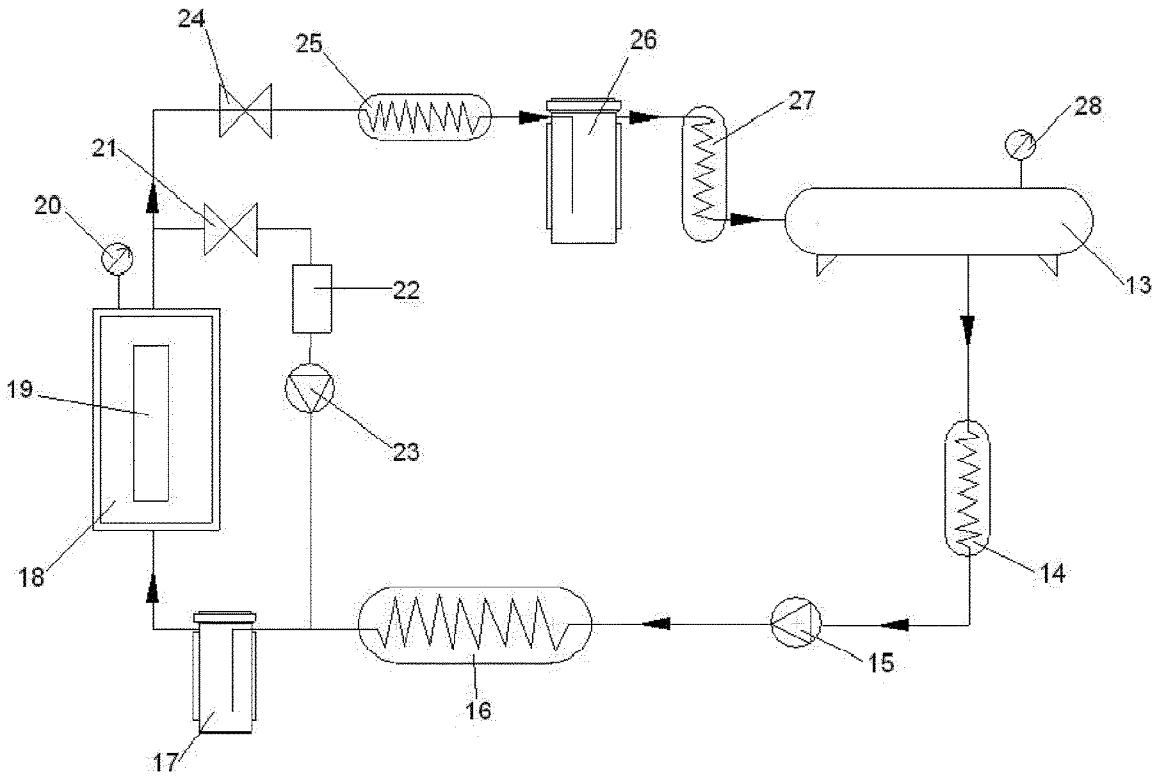

FIG. 2

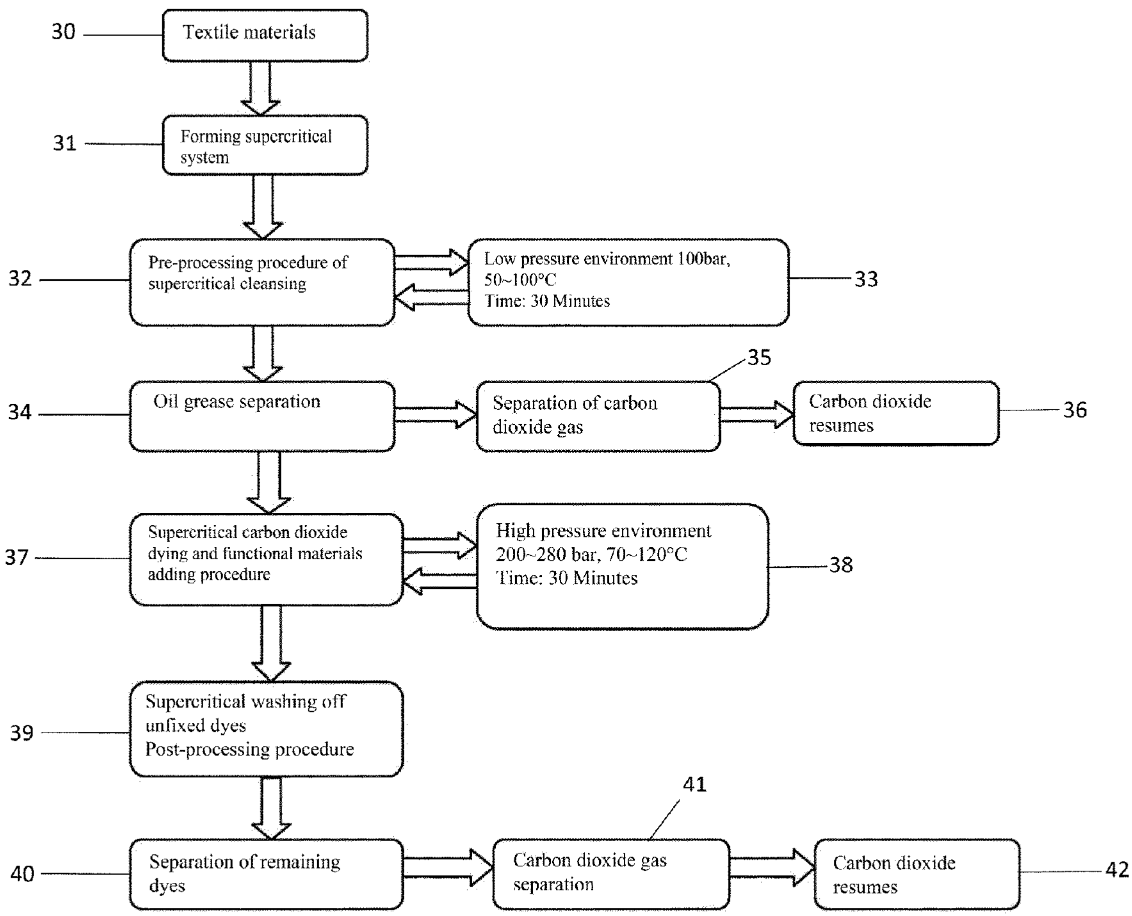
30
Textile materials
31
Forming supercritical system
32
Pre-processing procedure of supercritical cleansing
Low pressure environment 100bar, 50~100°C
Time: 30 Minutes
33
34
Oil grease separation
35
Separation of carbon dioxide gas
Carbon dioxide resumes
36
37
Supercritical carbon dioxide dying and functional materials adding procedure
High pressure environment 200~280 bar, 70~120°C
Time: 30 Minutes
38
39
Supercritical washing off unfixed dyes
Post-processing procedure
40
Separation of remaining dyes
41
Carbon dioxide gas separation
Carbon dioxide resumes
42

FIG. 3

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 5344

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search	Date of completion of the search	Examiner
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