United States Patent	12390761
Kind Code	B2
Date of Patent	August 19, 2025
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Target gas separation method using deep cooling process

Abstract

A target gas separation method using a deep cooling process includes a first process operation including a first thawing operation of blocking the first gas inlet unit and introducing inlet gas to the second heat exchanger through the second gas inlet unit to thaw the second heat exchanger and a first freezing operation transferring gas flowing into the second heat exchanger to the first heat exchanger through the second connection pipe to freeze target gas in the first heat exchanger, and a second process operation including a second thawing operation of blocking the second gas inlet unit and introducing inlet gas to the first heat exchanger through the first gas inlet unit to thaw the first heat exchanger and a second freezing operation of transferring gas flowing into the first heat exchanger to the second heat exchanger through the first connection pipe to freeze the target gas in the second heat exchanger, and wherein, after the first process operation is performed for a designated time, the second process operation is performed for another designated time.

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Appl. No.: **18/348685**

Filed: **July 07, 2023**

Prior Publication Data

Document Identifier	Publication Date
US 20240017207 A1	Jan. 18, 2024

Foreign Application Priority Data

KR	10-2022-0085876	Jul. 12, 2022

Publication Classification

Int. Cl.: **B01D53/00** (20060101); **B01D53/26** (20060101)

U.S. Cl.:

CPC **B01D53/265** (20130101); B01D2256/22 (20130101); B01D2257/80 (20130101)

Field of Classification Search

CPC: B01D (2256/22); B01D (2257/80); B01D (53/265)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

(1) This application is based on and claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2022-0085876, filed on 12 Jul. 2022, in the Korean Intellectual Property Office, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

1. Field

(2) The disclosure relates to a target gas separation method using a deep cooling process, and more particularly, to a target gas separation method using a deep cooling process, which separates moisture gas from natural gas, flue gas, and synthetic gas while repeatedly freezing and thawing a heat exchanger in the deep cooling process.

2. Description of the Related Art

(3) Carbon dioxide is included in natural gas, flue gas, and synthetic gas, and technology to capture carbon dioxide with high purity from natural gas, flue gas, and synthetic gas has been developed.

(4) Depending on transportation or use, carbon dioxide with high purity needs to remove moisture at a concentration of 20 ppm mol or less or 500 ppm mol or less, and carbon dioxide with high purity of 95% mol or more or 99.5% mol or more is required.

(5) In particular, when moisture is mixed with carbon dioxide, the moisture may be frozen at a low temperature or CO_2 hydrate is generated to cause clogging of pipes or equipment, and thus moisture removal is essential in a process of capturing carbon dioxide.
(6) A method of removing moisture from an inlet gas includes a method of removing moisture by passing the inlet gas through a moisture adsorption tower filled with moisture adsorbent. However, when moisture is removed through the above method, several stages of adsorption towers must be used to remove moisture to tens of ppm or less.
(7) In addition, to regenerate the adsorbent adsorbed with moisture, a dry gas must be heated and re-introduced into the moisture adsorption tower, so there is a loss of dry gas or an increase in the circulation amount of devices, and the adsorbent needs to be replaced after use for a certain period.
(8) Another method of removing moisture from an inlet gas includes a method of condensing and removing moisture in a heat exchanger. In this method, a temperature in the heat exchanger must be set to 0 degrees or more to prevent moisture from freezing.
(9) However, it is difficult to remove moisture to tens of ppm or less through the method of cooling moisture to 0 degrees or more. To remove moisture to tens of ppm or less, the heat exchanger must be cooled to 0 degrees or less, but when the heat exchanger is cooled to 0 degrees or less, moisture is frozen on a heat exchange surface of the heat exchanger.
(10) To thaw the frozen moisture, an inlet gas must be blocked, hot water must be introduced into a space where a refrigerant is introduced and then the refrigerant is supplied again after thawing is completed, and thus the refrigerant easily is lost or contaminated. Also, the temperature of the space in which moisture is frozen inside the heat exchanger does not rise easily, and thus thawing requires a lot of time.

SUMMARY

(11) Provided is a target gas separation method using a deep cooling process, which separates moisture gas from natural gas, flue gas, and synthetic gas while repeatedly freezing and thawing a heat exchanger in the deep cooling process.
(12) Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments of the disclosure.
(13) According to an aspect of the disclosure, a target gas separation method using a deep cooling process is a method of separating gas through a gas separation device configured to separate gas by using a deep cooling process, wherein the gas separation device includes a first heat exchanger configured to cool inlet gas, a first gas inlet unit connected to the first heat exchanger and configured to introduce the inlet gas into the first heat exchanger, a second heat exchanger configured to cool inlet gas, a second gas inlet unit connected to the second heat exchanger and configured to introduce the inlet gas to the second heat exchanger, a first connection pipe configured to transfer gas from the first heat exchanger to the second heat exchanger, and a second connection pipe configured to transfer gas from the second heat exchanger to the first heat exchanger, the target gas separation method including a first process operation including a first thawing operation of blocking the first gas inlet unit and introducing inlet gas to the second heat exchanger through the second gas inlet unit to thaw the second heat exchanger and a first freezing operation transferring gas flowing into the second heat exchanger to the first heat exchanger through the second connection pipe to freeze target gas in the first heat exchanger, and a second process operation including a second thawing operation of blocking the second gas inlet unit and introducing inlet gas to the first heat exchanger through the first gas inlet unit to thaw the first heat exchanger and a second freezing operation of transferring gas flowing into the first heat exchanger to the second heat exchanger through the first connection pipe to freeze the target gas in the second heat exchanger, and wherein, after the first process operation is performed for a designated time, the second process operation is performed for another designated time.
(14) In the target gas separation method using a deep cooling process, the first process operation

and the second process operation may be alternately performed.
(15) In the target gas separation method using a deep cooling process, the target gas may include moisture.
(16) In the target gas separation method using a deep cooling process, the first gas inlet unit and the second gas inlet unit may be connected to a compressor.
(17) In the target gas separation method using a deep cooling process, the first gas inlet unit may include a first opening/closing valve configured to open and close the first gas inlet unit, and the second gas inlet unit may include a second opening/closing valve configured to open and close the second gas inlet unit.
(18) In the target gas separation method using a deep cooling process, the first connection pipe may include a first connection valve configured to open and close the first connection pipe, and the second connection pipe may include a second connection valve configured to open and close the second connection pipe.
(19) In the target gas separation method using a deep cooling process, the first connection pipe and the second connection pipe may be connected to a connection compressor.
(20) In the target gas separation method using a deep cooling process, the first connection pipe may include a first compressor connection valve configured to open and close the first connection pipe at a front end of the connection compressor, and the second connection pipe may include a second compressor connection valve configured to open and close the second connection pipe at the front end of the connection compressor.
(21) In the target gas separation method using a deep cooling process, the gas separation device may further include a first branch pipe connected to the second heat exchanger and branched from the first connection pipe, and a second branch pipe connected to the first heat exchanger and branched from the second connection pipe, wherein the first branch pipe may include a first branch pipe valve configured to open and close the first branch pipe, and the second branch pipe may include a second branch pipe valve configured to open and close the second branch pipe.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The above and other aspects, features, and advantages of certain embodiments of the disclosure will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:
(2) FIG. **1** is a diagram illustrating a gas separation device according to an embodiment;
(3) FIG. **2** is a process chart of a target gas separation method using a deep cooling process, according to an embodiment;
(4) FIG. **3** is a diagram of a target gas separation device in which a connection compressor is connected to a first connection pipe and a second connection pipe, according to an embodiment; and
(5) FIG. **4** is a diagram of a gas separation device which further includes a second branch pipe branched from the second connection pipe and a first branch pipe branched from the first connection pipe, according to another embodiment.
DETAILED DESCRIPTION
(6) Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

Expressions such as “at least one of,” when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.
(7) The disclosure will be described more fully with reference to embodiments. The disclosure may, however, be embodied in many different forms and should not be construed as being limited to the exemplary embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the inventive concept to one of ordinary skill in the art.
(8) Expressions such as “include” or “may include” that may be used in various embodiments of the disclosure indicate the existence of a function, operation, or component that has been disclosed, and does not limit one or more additional functions, operations, or components. Also, in various embodiments of the disclosure, terms such as “include” or “have” are intended to designate the existence of features, numbers, steps, operations, components, parts, or combinations thereof described in the disclosure, and it should be understood that the presence or addition of one or more other features, numbers, steps, operations, components, parts, or combinations thereof is not precluded.
(9) When a component is referred to as being “connected or coupled” to another component, the component may be directly connected or coupled to the other component, but it should be understood that another new component may exist between the certain component and the other component. On the contrary, when a component is referred to as being “directly connected” or “directly couple” to another component, it should be understood that no new component exists between the component and the other component.
(10) It will be understood that although the terms “first,” “second,” etc. may be used herein to describe various components, these components should not be limited by these terms. These components are only used to distinguish one component from another.
(11) The disclosure relates to a target gas separation method using a deep cooling process, and more particularly, to a target gas separation method using a deep cooling process, which separates moisture gas from natural gas, flue gas, and synthetic gas while repeatedly freezing and thawing a heat exchanger in the deep cooling process.
(12) To separate carbon dioxide (CO.sub.2) with high purity from natural gas, flue gas, and synthetic gas, moisture must be separated before separating carbon dioxide.
(13) In the target gas separation method using a deep cooling process according to an embodiment, the target gas may be moisture, and the target gas separation method using a deep cooling process according to an embodiment may be a method of separating moisture before separating carbon dioxide (CO.sub.2) from natural gas, flue gas, or synthetic gas.
(14) The target gas of the target gas method using a deep cooling process according to an embodiment may be moisture gas, but is not necessarily limited thereto. The target gas separation method using a deep cooling process according to an embodiment may also be applied to a method of separating gas that is not moisture but has properties similar to moisture. Hereinafter, the disclosure will now be described more fully with reference to the accompanying drawings, in which embodiments of the inventive concept are shown.
(15) Referring to FIGS. **1** and **2**, the gas separation method using a deep cooling process according to an embodiment includes inflow operation S**110**, freezing operation S**120**, first process operation S**130**, and second process operation S**140**.
(16) The gas separation method using a deep cooling process according to an embodiment is a method of separating gas through a gas separation device configured to separate a target gas by using a deep cooling process, and the gas separation device includes a first heat exchanger **110**, a first gas inlet unit **120**, a first connection pipe **130**, a second heat exchanger **140**, a second gas inlet unit **150**, and a second connection pipe **160**.
(17) The first heat exchanger **110** cools inlet gas, and a refrigerant may flow into the first heat exchanger **110**. The first heat exchanger **110** may cool inlet gas through the refrigerant.

(18) The first gas inlet unit **120** may introduce inlet gas into the first heat exchanger **110** while being connected to the first heat exchanger **110**. The first gas inlet unit **120** is a pipe connected to the first heat exchanger **110**, and inlet gas may flow into the first heat exchanger **110** through the first gas inlet unit **120**.
(19) The first gas inlet unit **120** may include a first opening/closing valve **121** that opens and closes the first gas inlet unit **120**. The first gas inlet unit **120** may be opened or closed through the first opening/closing valve **121**.
(20) The first connection pipe **130** transfers gas from the first heat exchanger **110** to the second heat exchanger **140**. The first connection pipe **130** may be a pipe that may transfer gas discharged from the first heat exchanger **110** to the second heat exchanger **140**, and the first heat exchanger **110** and the second heat exchanger **140** may be connected to each other through the first connection pipe **130**.
(21) The first connection pipe **130** may include a first connection valve **131** that opens and closes the first connection pipe **130**. The first connection pipe **130** may be opened and closed through the first connection valve **131**, and the flow of gas from the first heat exchanger **110** to the second heat exchanger **140** may be adjusted through the first connection valve **131**.
(22) The gas separation device may further include a first gas discharge pipe **191** and a first liquid discharge pipe **181**. The first gas discharge pipe **191** is a pipe branched from the first connection pipe **130** and discharges gas from the first heat exchanger **110** to the outside.
(23) The first gas discharge pipe **191** may include a first gas discharge valve **192** that opens and closes the first gas discharge pipe **191**. The first gas discharge pipe **191** may be opened and closed through the first gas discharge valve **192**, and accordingly, the discharge of gas from the first heat exchanger **110** to the outside may be adjusted.
(24) In particular, when the first connection valve **131** of the first connection pipe **130** is opened and the first gas discharge valve **192** is closed, gas from the first heat exchanger **110** may flow into the second heat exchanger **140** through the first connection pipe **130**.
(25) On the contrary, when the first connection valve **131** of the first connection pipe **130** is closed and the first gas discharge valve **192** is opened, gas from the first heat exchanger **110** may be discharged to the outside.
(26) The first liquid discharge pipe **181** may discharge liquid generated in the first heat exchanger **110** to the outside. The first liquid discharge pipe **181** may include a first liquid discharge valve **182** that opens and closes the first liquid discharge pipe **181**. The first liquid discharge pipe **181** may be opened and closed through the first liquid discharge valve **182**, and accordingly, the discharge of liquid from the first heat exchanger **110** to the outside may be adjusted.
(27) The second heat exchanger **140** cools inlet gas, and a refrigerant may flow into the second heat exchanger **140**. The second heat exchanger **140** may cool inlet gas through the refrigerant.
(28) The second gas inlet unit **150** may introduce inlet gas into the second heat exchanger **140** while being connected to the second heat exchanger **140**. The second gas inlet unit **150** is a pipe connected to the second heat exchanger **140**, and inlet gas may flow into the second heat exchanger **140** through the second gas inlet unit **150**.
(29) The second gas inlet unit **150** may include a second opening/closing valve **151** that opens and closes the second gas inlet unit **150**. The second gas inlet unit **150** may be opened or closed through the second opening/closing valve **151**.
(30) The second connection pipe **160** transfers gas from the second heat exchanger **140** to the first heat exchanger **110**. The second connection pipe **160** may be a pipe that may transfer gas discharged from the second heat exchanger **140** to the first heat exchanger **110**, and the second heat exchanger **140** and the first heat exchanger **110** may be connected to each other through the second connection pipe **160**.
(31) The second connection pipe **160** may include a second connection valve **161** that opens and closes the second connection pipe **160**. The second connection pipe **160** may be opened and closed

through the second connection valve **161**, and the flow of gas from the second heat exchanger **140** to the first heat exchanger **110** may be adjusted through the second connection valve **161**.

(32) The gas separation device may further include a second gas discharge pipe **193** and a second liquid discharge pipe **183**. The second gas discharge pipe **193** is a pipe branched from the second connection pipe **160** and discharges gas from the second heat exchanger **140** to the outside.

(33) The second gas discharge pipe **193** may include a second gas discharge valve **194** that opens and closes the second gas discharge pipe **193**. The second gas discharge pipe **193** may be opened and closed through the second gas discharge valve **194**, and accordingly, the discharge of gas from the second heat exchanger **140** to the outside may be adjusted.

(34) In particular, when the second connection valve **161** of the second connection pipe **160** is opened and the second gas discharge valve **194** is closed, gas from the second heat exchanger **140** may flow into the first heat exchanger **110** through the second connection pipe **160**.

(35) On the contrary, when the second connection valve **161** of the second connection pipe **160** is closed and the second gas discharge valve **194** is opened, gas from the second heat exchanger **140** may be discharged to the outside.

(36) The second liquid discharge pipe **183** may discharge liquid generated in the second heat exchanger **140** to the outside. The second liquid discharge pipe **183** may include a second liquid discharge valve **184** that opens and closes the second liquid discharge pipe **183**. The second liquid discharge pipe **183** may be opened and closed through the second liquid discharge valve **184**, and accordingly, the discharge of liquid from the second heat exchanger **140** to the outside may be adjusted.

(37) The first gas inlet unit **120** and the second gas inlet unit **150** of the gas separation device may also be connected to a compressor **170**. However, the compressor **170** may or may not be used as needed.

(38) Referring to FIG. **3**, the first connection pipe **130** and the second connection pipe **160** of the gas separation device may be connected to a connection compressor **171**. At this time, the first connection pipe **130** and the second connection pipe **160** may be connected to one connection compressor **171**.

(39) The first connection pipe **130** and the second connection pipe **160** may share one connection compressor **171**, and the first connection pipe **130** and the second connection pipe **160** may be connected to each other through one connection compressor **171**.

(40) Referring to FIG. **3**, the first connection pipe **130** may include a first compressor connection valve **132** opening and closing the first connection pipe **130** at a front end of the connection compressor **171**. The first connection pipe **130** may be opened and closed at the front end of the connection compressor **171** through the first compressor connection valve **132**, and accordingly, supply of gas to the connection compressor **171** may be adjusted.

(41) The second connection pipe **160** may include a second compressor connection valve **162** opening and closing the second connection pipe **160** at the front end of the connection compressor **171**. The second connection pipe **160** may be opened and closed at the front end of the connection compressor **171** through the second compressor connection valve **162**, and accordingly, the supply of gas to the connection compressor **171** may be adjusted.

(42) Referring to FIG. **4**, the gas separation device further includes a first branch pipe **133** branched from the first connection pipe **130** and connected to the second heat exchanger **140**, and a second branch pipe **163** branched from the second connection pipe **160** and connected to the first heat exchanger **110**.

(43) The first branch pipe **133** may include a first branch pipe valve **134** that opens and closes the first branch pipe **133**, and the second branch pipe **163** may include a second branch pipe valve **164** that opens and closes the second branch pipe **163**.

(44) The second branch pipe **163** may re-introduce gas discharged from the first heat exchanger **110** to the first heat exchanger **110** again. In particular, gas discharged from the first heat exchanger **110**

may flow into the connection compressor **171** through the first connection pipe **130**. At this time, the first compressor connection valve **132** is open, and the second compressor connection valve **162** is closed.
(45) The connection compressor **171** is connected to the first connection pipe **130** and the second connection pipe **160**, and gas flowing into the connection compressor **171** may move along the first connection pipe **130** and the second connection pipe **160**.
(46) Referring to FIG. **4**, gas moving through the first connection pipe **130** flows into the second heat exchanger **140**. At this time, the first branch pipe valve **134** is closed, and the first connection valve **131** is open. Gas moving along the second connection pipe **160** may flow into the first heat exchanger **110** by moving along the second branch pipe **163**. At this time, the second branch pipe valve **164** is open, and the second connection valve **161** is closed.
(47) As such, gas discharged from the first heat exchanger **110** may reflow into the first heat exchanger **110** through the first connection pipe **130**—the connection compressor **171**—the second connection pipe **160**—the second branch pipe **163**.
(48) The first branch pipe **133** may re-introduce gas discharged from the second heat exchanger **140** to the second heat exchanger **140** again. In particular, gas discharged from the second heat exchanger **140** may flow into the connection compressor **171** through the second connection pipe **160**. At this time, the second compressor connection valve **162** is open, and the first compressor connection valve **132** is closed.
(49) The connection compressor **171** is connected to the first connection pipe **130** and the second connection pipe **160**, and gas flowing into the connection compressor **171** may move along the second connection pipe **160** and the first connection pipe **130**.
(50) Referring to FIG. **4**, gas moving through the second connection pipe **160** flows into the first heat exchanger **110**. At this time, the second branch pipe valve **164** is closed, and the second connection valve **161** is open. Gas moving along the first connection pipe **130** may flow into the second heat exchanger **140** by moving along the first branch pipe **133**. At this time, the first branch pipe valve **134** is open, and the first connection valve **131** is closed.
(51) As such, gas discharged from the second heat exchanger **140** may reflow into the second heat exchanger **140** through the second connection pipe **160**—the connection compressor **171**—the first connection pipe **130**—the first branch pipe **133**.
(52) Hereinafter, a target gas separation method using a deep cooling process according to an embodiment using the gas separation device described above is described in detail.
(53) FIGS. **1**, **3**, and **4** are diagrams showing a method of separating moisture from inlet gas through the target gas separation method using a deep cooling process according to an embodiment. In the target gas separation method using a deep cooling process according to an embodiment, the target gas to be separated may be moisture. However, the disclosure is not limited thereto, and in the target gas separation method using a deep cooling process according to an embodiment, the target gas to be separated may be gas having properties similar to moisture.
(54) Hereinafter, as shown in FIGS. **1**, **3**, and **4**, a method of using moisture as target gas and separating moisture from inlet gas is mainly described.
(55) Inlet gas flowing into the gas separation device is gas in which moisture, such as nitrogen, oxygen, carbon monoxide, hydrogen, hydrocarbon, nitrogen oxide, sulfur oxide, carbonyl sulfide (COS), hydrogen sulfide (H.sub.2S), carbon disulfide (CS.sub.2), or the like, is mixed with carbon dioxide.
(56) To separate carbon dioxide (CO.sub.2) with high purity from natural gas, flue gas, and synthetic gas, moisture must be separated before separating carbon dioxide. The target gas separation method using a deep cooling process according to an embodiment may be a method of separating moisture before separating carbon dioxide (CO.sub.2) from natural gas, flue gas, and synthetic gas.
(57) Inlet gas flowing into the gas separation device may flow into any one of the first gas inlet unit

120 and the second gas inlet unit **150**. In particular, when the first opening/closing valve **121** of the first gas inlet unit **120** is open and the second opening/closing valve **151** of the second gas inlet unit **150** is closed, the inlet gas may flow into the first gas inlet unit **120**.
(58) On the contrary, when the first opening/closing valve **121** of the first gas inlet unit **120** is closed and the second opening/closing valve **151** of the second gas inlet unit **150** is open, the inlet gas may flow into the second gas inlet unit **150**.
(59) Referring to FIG. **2**, inflow operation S**110** of the target gas separation method using a deep cooling process according to an embodiment is an operation of introducing inlet gas to the first heat exchanger **110** through the first gas inlet unit **120**.
(60) By opening the first opening/closing valve **121** of the first gas inlet unit **120** and closing the second opening/closing valve **151** of the second gas inlet unit **150**, the inlet gas is introduced into the first gas inlet unit **120**. At this time, the compressor **170** may or may not be connected to the first gas inlet unit **120** and the second gas inlet unit **150**.
(61) In the first heat exchanger **110**, target gas may be primarily removed, and gas from which target gas is primarily removed in the first heat exchanger **110** is transferred to the second heat exchanger **140** by moving along the first connection pipe **130**.
(62) In particular, moisture, which is the target gas, may be primarily removed in the first heat exchanger **110**, and gas from which moisture is primarily removed in the first heat exchanger **110** is transferred to the second heat exchanger **140** by moving along the first connection pipe **130**.
(63) A refrigerant may be supplied to the first heat exchanger **110**, and target gas among gases flowing into the first heat exchanger **110** is condensed through the refrigerant. Here, in the first heat exchanger **110**, freezing does not occur, and only condensation of the target gas may occur.
(64) That is, only condensation instead of freezing occurs in the first heat exchanger **110** by adjusting refrigerant supplied to the first heat exchanger **110**. According to an embodiment, when target gas is moisture, the temperature of gas discharged from the first heat exchanger **110**, from which moisture is removed, may be equal to or greater than 0 degrees by adjusting the temperature or flow rate of refrigerant supplied to the first heat exchanger **110**.
(65) Also, the temperature or flow rate of the refrigerant supplied to the first heat exchanger **110** may be adjusted so that the temperature of gas discharged from the first heat exchanger **110** through the first connection pipe **130** is less than the temperature of inlet gas.
(66) Freezing operation S**120** is an operation of transferring inlet gas flowing into the first heat exchanger **110** to the second heat exchanger **140** through the first connection pipe **130** to freeze the target gas in the second heat exchanger **140**.
(67) The target gas may be primarily removed in the first heat exchanger **110**, and the gas from which the target gas is primarily removed may be transferred to the second heat exchanger **140** through the first connection pipe **130**. The target gas may be removed once more by freezing the target gas in the second heat exchanger **140**, and gas from which the target gas is removed may be discharged through the second gas discharge pipe **193**.
(68) In particular, moisture, which is the target gas, may be primarily removed in the first heat exchanger **110**, and gas from which moisture is primarily removed in the first heat exchanger **110** is transferred to the second heat exchanger **140** by moving along the first connection pipe **130**. When gas from which moisture is primarily removed is transferred from the first heat exchanger **110** by moving along the first connection pipe **130**, the first connection valve **131** may be opened, and the first gas discharge valve **192** may be closed.
(69) Moisture may be removed once more by freezing the moisture in the second heat exchanger **140**, and gas from which moisture is removed may be discharged through the second gas discharge pipe **193**.
(70) A refrigerant may be supplied to the second heat exchanger **140**, and target gas among gases flowing into the second heat exchanger **140** is frozen by the refrigerant. According to an embodiment, when the target gas is moisture, moisture is frozen in the second heat exchanger **140**

by adjusting refrigerant supplied to the second heat exchanger **140**. At this time, the temperature of gas discharged from the second heat exchanger **140**, from which moisture is removed, may be lower than 0 degrees, which is a temperature at which moisture may be frozen.
(71) After inflow operation S**110** and freezing operation S**120**, first process operation S**130** may be performed. Here, inflow operation S**110** and freezing operation S**120** are operations in which freezing occurs before first process operation S**140** and second process operation S**150**. When freezing has already occurred in the second heat exchanger **140**, inflow operation S**110** and freezing operation S**120** may be omitted, and first process operation S**140** and second process operation S**150** may be performed.
(72) Referring to FIG. first process operation S**130** include first thawing operation S**131** and first freezing operation S**132**.
(73) First thawing operation S**131** is an operation in which the first gas inlet unit **120** is blocked and inlet gas is introduced into the second heat exchanger **140** through the second gas inlet unit **150** to thaw the second heat exchanger **140**.
(74) Referring to FIG. **1**, by closing the first opening/closing valve **121** of the first gas inlet unit **120** and opening the second opening/closing valve **151** of the second gas inlet unit **150**, the inlet gas is introduced into the second gas inlet unit **150**. At this time, the compressor **170** may or may not be connected to the first gas inlet unit **120** and the second gas inlet unit **150**.
(75) The second heat exchanger **140** is in a state in which freezing has occurred, and inlet gas flowing into the second heat exchanger **140** may have a temperature greater than a freezing temperature of the target gas. As the inlet gas is introduced into the second heat exchanger **140**, the second heat exchanger **140** may be thawed. At this time, in the second heat exchanger **140**, condensation of the target gas also occurs, so that the target gas may be primarily removed from the inlet gas.
(76) A refrigerant may be supplied to the second heat exchanger **140**, and target gas among gases flowing into the second heat exchanger **140** is condensed through the refrigerant. Here, in the second heat exchanger **140**, freezing does not occur, and only condensation of the target gas may occur. That is, the target gas may be condensed from the inlet gas while the second heat exchanger **140** is thawed by adjusting the temperature or flow rate of refrigerant supplied to the second heat exchanger **140**.
(77) Because a temperature at which the target gas is condensed is greater than a freezing temperature, thawing may occur in the second heat exchanger **140**. In particular, the second heat exchanger **140** is thawed while using the inlet gas flowing into the second heat exchanger **140** as a sweep gas, and at the same time, the target gas may be condensed from the inlet gas.
(78) Gas from which the target gas is primarily removed in the second heat exchanger **140** is transferred to the first heat exchanger **110** by moving along the second connection pipe **160**. When the gas from which moisture is primarily removed is transferred from the second heat exchanger **140** by moving along the second connection pipe **160**, the second connection valve **161** may be opened, and the second gas discharge valve **194** may be closed.
(79) According to an embodiment, when the target gas is moisture, moisture frozen in the second heat exchanger **140** may be thawed by inlet gas flowing into the second heat exchanger **140**, and the moisture may be primarily removed while being condensed from the inlet gas flowing into the second heat exchanger **140**.
(80) The moisture thawed in the second heat exchanger **140** and the moisture condensed in the second heat exchanger **140** may be discharged through the second liquid discharge pipe **183**, and at this time, the second liquid discharge valve **184** may be opened. Gas from which moisture is primarily removed in the second heat exchanger **140** is transferred to the first heat exchanger **110** by moving along the second connection pipe **160**.
(81) Here, the temperature of gas discharged from the second heat exchanger **140**, from which moisture is primarily removed, may be greater than 0 degrees by adjusting refrigerant supplied to

the second heat exchanger **140**. Because moisture must be condensed in the second heat exchanger **140** while thawing occurs, the temperature of gas discharged from the second heat exchanger **140**, from which moisture is primarily removed, must be greater than 0 degrees.

(82) Also, the temperature or flow rate of the refrigerant supplied to the second heat exchanger **140** may be adjusted so that the temperature of gas discharged from the second heat exchanger **140** through the second connection pipe **160** is less than the temperature of inlet gas.

(83) When the temperature of gas discharged from the second heat exchanger **140** through the second connection pipe **160** is greater than the temperature of the inlet gas, the target gas included in the inlet gas may be discharged without being condensed. Also, while the target gas thawed in the second heat exchanger **140** is vaporized, the concentration of the target gas among gases discharged from the second heat exchanger **140** through the second connection pipe **160** may be greater than the concentration of the target gas among the inlet gas.

(84) Accordingly, the temperature or flow rate of refrigerant supplied to the second heat exchanger **140** is preferably adjusted so that the temperature of gas discharged from the second heat exchanger **140** through the second connection pipe **160** is less than the temperature of inlet gas.

(85) First freezing operation S**132** is an operation of transferring inlet gas flowing into the second heat exchanger **140** to the first heat exchanger **110** through the second connection pipe **160** to freeze the target gas in the first heat exchanger **110**.

(86) In the first heat exchanger **110**, the target gas may be removed once more through freezing. Gas from which the target gas is removed once more through freezing in the first heat exchanger **110** may be discharged through the first gas discharge pipe **191**. At this time, the first gas discharge valve **192** is open.

(87) In particular, moisture may be removed once more by freezing the moisture in the first heat exchanger **110**, and gas from which moisture is removed may be discharged through the first gas discharge pipe **191**. At this time, the first gas discharge valve **192** is open.

(88) The first gas discharge pipe **191** is connected to a gas discharge pipe **195** discharging gas to the outside, and gas containing carbon dioxide while from which moisture is removed may be discharged through the gas discharge pipe **195**.

(89) A refrigerant may be supplied to the first heat exchanger **110**, and the target gas among gases flowing into the first heat exchanger **110** may be frozen. According to an embodiment, when the target gas is moisture, moisture is frozen in the first heat exchanger **110** by adjusting refrigerant supplied to the first heat exchanger **110**. At this time, the temperature of gas discharged from the first heat exchanger **110**, form which moisture is removed, may be lower than 0 degrees, which is a temperature at which moisture may be frozen.

(90) In first process operation S**130**, first thawing operation S**131** may occur in the second heat exchanger **140**, and first freezing operation S**132** may occur in the first heat exchanger **110**.

(91) According to an embodiment, first thawing operation S**131** and first freezing operation S**132** of first process operation S**130** may be simultaneously performed. That is, thawing may occur in the second heat exchanger **140**, and freezing may occur in the first heat exchanger **110**.

(92) Referring to FIG. **2**, second process operation S**140** includes second thawing operation S**141** and second freezing operation S**142**.

(93) Second thawing operation S**141** is an operation in which the second gas inlet unit **150** is blocked and inlet gas is introduced into the first heat exchanger **110** through the first gas inlet unit **120** to thaw the first heat exchanger **110**.

(94) Referring to FIG. **1**, by opening the first opening/closing valve **121** of the first gas inlet unit **120** and closing the second opening/closing valve **151** of the second gas inlet unit **150**, the inlet gas is introduced into the first gas inlet unit **120**. At this time, the compressor **170** may or may not be connected to the first gas inlet unit **120** and the second gas inlet unit **150**.

(95) The first heat exchanger **110** is in a state in which freezing has occurred, and inlet gas flowing into the first heat exchanger **110** may have a temperature greater than a freezing temperature of the

target gas. As the inlet gas is introduced into the first heat exchanger **110**, the first heat exchanger **110** may be thawed. At this time, in the first heat exchanger **110**, condensation of the target gas also occurs, so that the target gas may be primarily removed from the inlet gas.

(96) A refrigerant may be supplied to the first heat exchanger **110**, and target gas among gases flowing into the first heat exchanger **110** is condensed through the refrigerant. Here, in the first heat exchanger **110**, freezing does not occur, and only condensation of the target gas may occur. That is, the target gas may be condensed from the inlet gas while the first heat exchanger **110** is thawed by adjusting the temperature or flow rate of refrigerant supplied to the first heat exchanger **110**.

(97) Because a temperature at which the target gas is condensed is greater than a freezing temperature, thawing may occur in the first heat exchanger **110**. In particular, the first heat exchanger **110** is thawed while using the inlet gas flowing into the first heat exchanger **110** as a sweep gas, and at the same time, the target gas may be condensed from the inlet gas.

(98) Gas from which the target gas is primarily removed in the first heat exchanger **110** is transferred to the second heat exchanger **140** by moving along the first connection pipe **130**. When gas from which moisture is primarily removed is transferred from the first heat exchanger **110** by moving along the first connection pipe **130**, the first connection valve **131** may be opened, and the first gas discharge valve **192** may be closed.

(99) According to an embodiment, when the target gas is moisture, moisture frozen in the first heat exchanger **110** may be thawed by inlet gas flowing into the first heat exchanger **110**, and the moisture may be primarily removed while being condensed from the inlet gas flowing into the first heat exchanger **110**.

(100) The moisture thawed in the first heat exchanger **110** and the moisture condensed in the first heat exchanger **110** may be discharged through the first liquid discharge pipe **181**, and at this time, the first liquid discharge valve **182** may be opened. Gas from which the moisture is primarily removed in the first heat exchanger **110** is transferred to the second heat exchanger **140** by moving along the first connection pipe **130**.

(101) Here, the temperature of gas discharged from the first heat exchanger **110**, from which moisture is primarily removed, may be greater than 0 degrees by adjusting refrigerant supplied to the first heat exchanger **110**. Because moisture must be condensed in the first heat exchanger **110** while thawing occurs, the temperature of gas discharged from the first heat exchanger **110**, from which moisture is primarily removed, must be greater than 0 degrees.

(102) Also, the temperature or flow rate of the refrigerant supplied to the first heat exchanger **110** may be adjusted so that the temperature of gas discharged from the first heat exchanger **110** through the first connection pipe **130** is less than the temperature of inlet gas.

(103) When the temperature of gas discharged from the first heat exchanger **110** through the first connection pipe **130** is greater than the temperature of the inlet gas, the target gas included in the inlet gas may be discharged without being condensed. Also, while the target gas thawed in the first heat exchanger **110** is vaporized, the concentration of the target gas among gases discharged from the first heat exchanger **110** through the first connection pipe **130** may be greater than the concentration of the target gas among the inlet gas.

(104) Accordingly, the temperature or flow rate of refrigerant supplied to the first heat exchanger **110** is preferably adjusted so that the temperature of gas discharged from the first heat exchanger **110** through the first connection pipe **130** is less than the temperature of inlet gas.

(105) Second freezing operation S**142** is an operation of transferring inlet gas flowing into the first heat exchanger **110** to the second heat exchanger **140** through the first connection pipe **130** to freeze the target gas in the second heat exchanger **140**.

(106) In the second heat exchanger **140**, the target gas may be removed once more through freezing. Gas from which the target gas is removed once more through freezing in the second heat exchanger **140** may be discharged through the second gas discharge pipe **193**. At this time, the second gas discharge valve **194** is open.

(107) In particular, moisture may be removed once more by freezing the moisture in the second heat exchanger **140**, and gas from which moisture is removed may be discharged through the second gas discharge pipe **193**. At this time, the second gas discharge valve **194** is open.
(108) The second gas discharge pipe **193** is connected to the gas discharge pipe **195** discharging gas to the outside, and gas containing carbon dioxide while from which moisture is removed may be discharged through the gas discharge pipe **195**.
(109) A refrigerant may be supplied to the second heat exchanger **140**, and the target gas among gases flowing into the second heat exchanger **140** may be frozen. According to an embodiment, when the target gas is moisture, moisture is frozen in the second heat exchanger **140** by adjusting refrigerant supplied to the second heat exchanger **140**. At this time, the temperature of gas discharged from the second heat exchanger **140**, from which moisture is removed, may be lower than 0 degrees, which is a temperature at which moisture may be frozen.
(110) In second process operation S**140**, second thawing operation S**141** may occur in the first heat exchanger **110**, and second freezing operation S**142** may occur in the second heat exchanger **140**.
(111) According to an embodiment, second thawing operation S**141** and second freezing operation S**141** of second process operation S**140** may be simultaneously performed. That is, thawing may occur in the first heat exchanger **110**, and freezing may occur in the second heat exchanger **140**.
(112) According to an embodiment, after first process operation S**130** is performed for a designated time, second process operation S**140** may be performed for another designated time. Also, first process operation S**130** may be performed again after second process operation S**140** is performed, and first process operation S**130** and second process operation S**140** may be alternately performed.
(113) Here, time for performing first process operation S**130** and time for performing second process operation S**140** may or may not be the same. According to an embodiment, the time for performing first process operation S**130** and second process operation S**140** may vary depending on a heat exchange area of the first heat exchanger **110** and a heat exchange area of the second heat exchanger **140**.
(114) As such, when first process operation S**130** and second process operation S**140** are alternately performed, target gas is repeatedly frozen and thawed in the first heat exchanger **110** and the second heat exchanger **140**.
(115) In particular, in first process operation S**130**, thawing of target gas occurs in the second heat exchanger **140**, and freezing of target gas occurs in the first heat exchanger **110**. In second process operation S**140**, thawing of target gas occurs in the first heat exchanger **110**, and freezing of target gas occurs in the second heat exchanger **140**.
(116) In the target gas separation method using a deep cooling process according to an embodiment, as freezing and thawing of target gas repeatedly occur in the first heat exchanger **110** and the second heat exchanger **140** by alternately performing first process operation S**120** and second process operation S**130**, separate hot water for thawing may not be used in the first heat exchanger **110** and the second heat exchanger **140**.
(117) In particular, in the target gas separation method using a deep cooling process according to an embodiment, as frozen target gas is thawed by using process gas present in the cooling process as sweep gas, it is not necessary to use separate hot water in the first heat exchanger **110** and the second heat exchanger **140**, and the target gas may be efficiently separated.
(118) However, the disclosure is not limited thereto, and before inlet gas is introduced into the first heat exchanger **110** or the second heat exchanger **140** through the first gas inlet unit **120** or the second gas inlet unit **150**, the inlet gas may also be heated by using a heat exchanger to increase a thawing effect.
(119) Accordingly, in the target gas separation method using a deep cooling process according to an embodiment, moisture may be removed from inlet gas to several tens of ppm or less, and loss or contamination of refrigerant may be prevented.
(120) Referring to FIG. **3**, the first connection pipe **130** and the second connection pipe **160** of the

gas separation device may be connected to the connection compressor **171**. At this time, the first connection pipe **130** and the second connection pipe **160** may be connected to one connection compressor **171**.
(121) The first connection pipe **130** and the second connection pipe **160** may share one connection compressor **171**, and the first connection pipe **130** and the second connection pipe **160** may be connected to each other through one connection compressor **171**.
(122) Referring to FIG. **3**, in first process operation S**130**, when transferring gas from which target gas is primarily removed to the first heat exchanger **110** through the second connection pipe **160**, the connection compressor **171** may be used.
(123) The connection compressor **171** may compress gas, and in first process operation S**130**, gas from which moisture is primarily removed may be transferred to the first heat exchanger **110** through the connection compressor **171**. At this time, the second compressor connection valve **162** may be opened, and the first compressor connection valve **132** may be closed.
(124) Referring to FIG. **3**, in second process operation S**140**, when transferring gas from which target gas is primarily removed to the second heat exchanger **140** through the first connection pipe **130**, the connection compressor **171** may also be used.
(125) The connection compressor **171** may compress gas, and in second process operation S**140**, gas from which moisture is primarily removed may be transferred to the second heat exchanger **140** through the connection compressor **171**. At this time, the first compressor connection valve **132** may be opened, and the second compressor connection valve **162** may be closed.
(126) Referring to FIG. **4**, the gas separation device further includes the first branch pipe **133** branched from the first connection pipe **130** and connected to the second heat exchanger **140**, and the second branch pipe **163** branched from the second connection pipe **160** and connected to the first heat exchanger **110**.
(127) The first branch pipe **133** may include a first branch pipe valve **134** that opens and closes the first branch pipe **133**, and the second branch pipe **163** may include a second branch pipe valve **164** that opens and closes the second branch pipe **163**.
(128) In first process operation S**130**, gas discharged from the second heat exchanger **140** is re-introduced into the second heat exchanger **140** through the first branch pipe **133**.
(129) In particular, the gas discharged from the second heat exchanger **140** in first process operation S**130** may flow into the connection compressor **171** through the second connection pipe **160**. At this time, the second compressor connection valve **162** is open, and the first compressor connection valve **132** is closed.
(130) The connection compressor **171** is connected to the first connection pipe **130** and the second connection pipe **160**, and gas flowing into the connection compressor **171** may move along the second connection pipe **160** and the first connection pipe **130**.
(131) Referring to FIG. **4**, gas moving through the second connection pipe **160** flows into the first heat exchanger **110**. At this time, the second branch pipe valve **164** is closed, and the second connection valve **161** is open. Gas moving along the first connection pipe **130** may reflow into the second heat exchanger **140** by moving along the first branch pipe **133**. At this time, the first branch pipe valve **134** is open, and the first connection valve **131** is closed.
(132) As such, gas discharged from the second heat exchanger **140** may reflow into the second heat exchanger **140** through the second connection pipe **160**—the connection compressor **171**—the first connection pipe **130**—the first branch pipe **133**.
(133) When the gas discharged from the second heat exchanger **140** in first process operation S**130** is re-introduced into the second heat exchanger **140** through the first branch pipe **133**, the second heat exchanger **140** may also be thawed through the re-introduced gas.
(134) Because the temperature of the gas re-introduced into the second heat exchanger **140** through the first branch pipe **133** has been increased by the connection compressor **171**, the gas may be used again as gas thawing the second heat exchanger **140**.

(135) In second process operation S**140**, gas discharged from the first heat exchanger **110** may be re-introduced into the first heat exchanger **110** through the second branch pipe **163**.
(136) In particular, the gas discharged from the first heat exchanger **110** in second process operation S**140** may flow into the connection compressor **171** through the first connection pipe **130**. At this time, the first compressor connection valve **132** is open, and the second compressor connection valve **162** is closed.
(137) The connection compressor **171** is connected to the first connection pipe **130** and the second connection pipe **160**, and gas flowing into the connection compressor **171** may move along the second connection pipe **160** and the first connection pipe **130**.
(138) Referring to FIG. **4**, gas moving through the first connection pipe **130** flows into the second heat exchanger **140**. At this time, the first branch pipe valve **134** is closed, and the first connection valve **131** is open. Gas moving along the second connection pipe **160** may reflow into the first heat exchanger **110** by moving along the second branch pipe **163**. At this time, the second branch pipe valve **164** is open, and the second connection valve **161** is closed.
(139) As such, gas discharged from the first heat exchanger **110** may reflow into the first heat exchanger **110** through the first connection pipe **130**—the connection compressor **171**—the second connection pipe **160**—the second branch pipe **163**.
(140) When the gas discharged from the first heat exchanger **110** in second process operation S**140** is re-introduced into to the first heat exchanger **110** through the second branch pipe **163**, the first heat exchanger **110** may also be thawed through the re-introduced gas.
(141) Because the temperature of the gas re-introduced into the first heat exchanger **110** through the second branch pipe **163** has been increased by the connection compressor **171**, the gas may be used again as gas thawing the first heat exchanger **110**.
(142) The target gas separation method using a deep cooling process according to the embodiment described above has the following effects.
(143) In the target gas separation method using a deep cooling process according to the embodiment, moisture may be separated from natural gas, flue gas, and synthetic gas while repeatedly freezing and thawing a heat exchanger in the deep cooling process.
(144) Also, in the target gas separation method using a deep cooling process according to the embodiment, as moisture is removed while repeatedly freezing and thawing the heat exchanger in the deep cooling process, moisture may be removed from inlet gas to several tens of ppm or less.
(145) In addition, in the target gas separation method using a deep cooling process according to the embodiment, as frozen moisture gas is thawed by using process gas preset in the cooling process as sweep gas, it is not necessary to use separate hot water, and moisture gas may be effectively separated.
(146) Also, in the target gas separation method using a deep cooling process according to the embodiment, as moisture is removed while repeatedly freezing and thawing the heat exchanger in the deep cooling process, loss or contamination of refrigerant may be prevented, and a space temperature of a space in which moisture is frozen inside the heat exchanger does not easily rise, and thus a problem that a lot of time is required for thawing may be solved.
(147) It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments. While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the disclosure as defined by the following claims.

Claims

1. A target gas separation method through a gas separation device configured to separate gas by using a deep cooling process, wherein the gas separation device comprises: a first heat exchanger configured to cool inlet gas; a first gas inlet unit connected to the first heat exchanger and configured to introduce the inlet gas into the first heat exchanger; a second heat exchanger configured to cool inlet gas; a second gas inlet unit connected to the second heat exchanger and configured to introduce the inlet gas to the second heat exchanger; a first connection pipe configured to transfer gas from the first heat exchanger to the second heat exchanger; and a second connection pipe configured to transfer gas from the second heat exchanger to the first heat exchanger, the method comprising: a first process operation comprising a first thawing operation of blocking the first gas inlet unit and introducing inlet gas to the second heat exchanger through the second gas inlet unit to thaw the second heat exchanger and a first freezing operation transferring gas flowing into the second heat exchanger to the first heat exchanger through the second connection pipe to freeze target gas in the first heat exchanger; and a second process operation comprising a second thawing operation of blocking the second gas inlet unit and introducing inlet gas to the first heat exchanger through the first gas inlet unit to thaw the first heat exchanger and a second freezing operation of transferring gas flowing into the first heat exchanger to the second heat exchanger through the first connection pipe to freeze the target gas in the second heat exchanger, and wherein, after the first process operation is performed for a designated time, the second process operation is performed for another designated time.
2. The target gas separation method of claim 1, wherein the first process operation and the second process operation are alternately performed.
3. The target gas separation method of claim 1, wherein the target gas comprises moisture.
4. The target gas separation method of claim 1, wherein the first gas inlet unit and the second gas inlet unit are connected to a compressor.
5. The target gas separation method of claim 1, wherein the first gas inlet unit comprises a first opening/closing valve configured to open and close the first gas inlet unit, and the second gas inlet unit comprises a second opening/closing valve configured to open and close the second gas inlet unit.
6. The target gas separation method of claim 1, wherein the first connection pipe comprises a first connection valve configured to open and close the first connection pipe, and the second connection pipe comprises a second connection valve configured to open and close the second connection pipe.
7. The target gas separation method of claim 1, wherein the first connection pipe and the second connection pipe are connected to a connection compressor.
8. The target gas separation method of claim 7, wherein the first connection pipe comprises a first compressor connection valve configured to open and close the first connection pipe at a front end of the connection compressor, and the second connection pipe comprises a second compressor connection valve configured to open and close the second connection pipe at the front end of the connection compressor.
9. The target gas separation method of claim 1, wherein the gas separation device further comprises a first branch pipe connected to the second heat exchanger and branched from the first connection pipe, and a second branch pipe connected to the first heat exchanger and branched from the second connection pipe, and wherein the first branch pipe comprises a first branch pipe valve configured to open and close the first branch pipe, and the second branch pipe comprises a second branch pipe valve configured to open and close the second branch pipe.