

APPARATUS AND METHOD FOR DIRECTLY CAPTURING CARBON DIOXIDE FROM AIR

[0001] This application claims the benefit of the priority to Chinese Patent Application No. 202111233307.2, titled “APPARATUS AND METHOD FOR DIRECTLY CAPTURING CARBON DIOXIDE FROM AIR”, filed with the China National Intellectual Property Administration on October 22, 2021, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present application relates to the technical field of environmental protection, atmospheric governance, and resource utilization, and in particular to an apparatus and method for directly capturing carbon dioxide from air.

BACKGROUND

[0003] The climate has undergone a significant change over the past century. According to the Fifth Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), the global surface temperature has increased by 0.85°C from 1880 to 2012, with the past three decades being warmer than any other decade since 1850, and the global sea level has risen by 0.19 meters from 1901 to 2010, and the area of Arctic sea ice has decreased by 3.5% to 4.1% every decade from 1979 to 2012.

[0004] In recent years, in response to the global climate warming, governments around the world have strengthened international cooperation and introduced a series of policies and regulations to restrain emission of greenhouse gases such as carbon dioxide. As explicitly stated in the Paris Agreement, the increase in global average temperature compared to the pre-industrial period should be controlled within 2°C, and efforts should be made to limit the temperature increase by no more than 1.5°C. The IPCC states that, in order to successfully reverse the trend of global temperature rise by the end of this century, carbon dioxide needs to be extracted entirely from the atmosphere.

[0005] As an effective countermeasure against the global climate change, extensive research and development work has been conducted on capturing, recovery, and utilization of carbon

dioxide in the air. For example, the patent publication No. CN102527191A discloses an apparatus for carbon dioxide recovery and a method for carbon dioxide recovery, which mainly utilize a solution to absorb carbon dioxide. This technical solution requires a large occupied area for equipment and thus does not have practical operability. As another example, the Carbon Engineering Co. in Canada utilizes a potassium hydroxide solution to adsorb carbon dioxide in the air, the regeneration process of which requires a large amount of thermal energy consumption, that is, it needs to heat a material to 900°C during the regeneration process.

SUMMARY

[0006] In view of the above, an object of the present invention is to provide an apparatus and a method for directly capturing carbon dioxide from air, which can achieve a direct capture of carbon dioxide from the air with a high capture rate and continuously produce carbon dioxide products with a high purity. Meanwhile, the apparatus has a compact arrangement of equipment, a small footprint, and has no waste solid or liquid discharge, which can reduce an equipment investment and a carbon dioxide capture cost.

[0007] An apparatus for directly capturing carbon dioxide from air is provided in the present application, including:

a thin-layer moving bed, which consists of a filter grating shell and a filter grating inner cylinder, wherein an annular gap is formed between the filter grating shell and the filter grating inner cylinder, and a spherical solid amine adsorbent is filled in the annular gap;

a high-level tank and multiple induced draft fans, which are provided on a top of the thin-layer moving bed, wherein a feeding pipe is provided at a lower part of the high-level tank and is in communication with an upper portion of the annular gap, an air outlet is provided at a top of the high-level tank and is in communication with the filter grating inner cylinder by means of the plurality of induced draft fans, and a quick separation connector is provided at an upper portion of the high-level tank;

a conical unloading port provided at a bottom of the thin-layer moving bed;

a desorber, which is provided with a feeding port in communication with the conical unloading port, wherein a heating coil, a CO₂ distribution pipe, and a filter cartridge are

provided inside the desorber, a CO₂ outlet is provided at a top of the desorber, and an adsorbent discharging port is provided at a bottom of the desorber; and

a cooler, which is provided with a feeding port in communication with the adsorbent discharging port, wherein a cooling pipe is provided in the cooler, and a top of the cooler is in communication with the quick separation connector of the high-level tank through a riser.

[0008] Preferably, the filter grating shell has a diameter ranging from 2.1m to 10.6m, and a filter grating clearance ranging from 30μm to 250μm;

the filter grating inner cylinder has a diameter ranging from 2m to 10m, and a filter grating clearance ranging from 30μm to 250μm;

the annular gap formed between the filter grating shell and the filter grating inner cylinder has a width ranging from 50mm to 300mm.

[0009] Preferably, the spherical solid amine adsorbent is a resin pellet solid amine adsorbent, and the spherical solid amine adsorbent has a particle size ranging from 200μm to 1000μm.

[0010] Preferably, the thin-layer moving bed has a height ranging from 10m to 25m.

[0011] Preferably, the air outlet is provided with a filter cartridge.

[0012] Preferably, a discharging pipe is provided at a bottom of the conical unloading port and is in communication with the feeding port of the desorber through a screw conveying pipe.

[0013] Preferably, the CO₂ distribution pipe is in communication with the CO₂ outlet through the filter cartridge.

[0014] Preferably, the adsorbent discharging port is in communication with the feeding port of the cooler through a screw conveying pipe.

[0015] A method for directly capturing carbon dioxide from air by using the apparatus as described above is further provided in the present application, comprising the following steps of:

bringing an air containing CO₂ into the thin-layer moving bed by transversely passing through the filter grating shell so as to be in contact with a spherical solid amine adsorbent for CO₂ adsorption, wherein a purified air after CO₂ capturing transversely passes through the filter grating inner cylinder and is discharged from the air outlet by means of the

induced draft fans;

moving the CO₂-adsorbed spherical solid amine adsorbent from top to bottom, into the desorber through the conical unloading port, and heating the CO₂-adsorbed spherical solid amine adsorbent by the heating coil so as to desorb CO₂ from the spherical solid amine adsorbent, wherein the CO₂ is discharged through the CO₂ outlet;

enabling the CO₂-desorbed spherical solid amine adsorbent to enter the cooler to be cooled, to be elevated to the high-level tank through the riser, and then to be conveyed to the upper part of the annular gap through the feeding pipe for recycling.

[0016] Preferably, a temperature heated by the heating coil is 110°C to 120°C, and a temperature cooled through the cooler is 30°C to 50°C.

[0017] An apparatus and method for directly capturing carbon dioxide from the air are provided in the present application. The apparatus includes: a thin-layer moving bed consisting of a filter grating shell and a filter grating inner cylinder, wherein an annular gap is formed between the filter grating shell and the filter grating inner cylinder, and a spherical solid amine adsorbent is filled in the annular gap; a high-level tank and multiple induced draft fans provided on a top of the thin-layer moving bed, wherein a feeding pipe is provided at a lower part of the high-level tank and is in communication with an upper portion of the annular gap, an air outlet is provided at a top of the high-level tank and is in communication with the filter grating inner cylinder by means of the multiple induced draft fans, and a quick separation connector is provided at an upper portion of the high-level tank; a conical unloading port provided at a bottom of the thin-layer moving bed; a desorber provided with a feeding port in communication with the conical unloading port, wherein a heating coil, a CO₂ distribution pipe, and a filter cartridge are provided inside the desorber, a CO₂ outlet is provided at a top of the desorber, and an adsorbent discharging port is provided at a bottom of the desorber; and a cooler provided with a feeding port in communication with the adsorbent discharging port, wherein a cooling pipe is provided in the cooler, and a top of the cooler is in communication with the quick separation connector of the high-level tank through a riser. Compared with the conventional technology, the apparatus provided in the present application adopts a specific structure and a connection relation and directly captures carbon dioxide from the air with a spherical solid amine thin-layer moving bed. It can realize a carbon dioxide capture with a high efficiency and in a large scale and can continuously

produce high-purity carbon dioxide products. Meanwhile, the apparatus has a compact arrangement and a small footprint, and has no waste solid or liquid discharge, which can reduce the equipment investment and carbon dioxide capture costs. The experimental result shows that the apparatus and method for directly capturing carbon dioxide from the air provided in the present application have a CO₂ capture rate of 70% to 90% and can produce CO₂ products with a purity of 95% to 99%.

[0018] Furthermore, the present invention adopts a special heat exchange process, which greatly increases the energy utilization rate. An axial flow induced draft fan with a large flow rate and a low wind pressure head may be applied to a large-scale CO₂ capture, which has a broad application prospect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. 1 is a schematic structural view of an apparatus for directly capturing carbon dioxide from air provided in an embodiment of the present application; and

[0020] FIG. 2 is a schematic diagram showing a working process of the apparatus for directly capturing carbon dioxide from air provided in the embodiment of the present application.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0021] A clear and complete description to the technical solutions of the present application will be given below in conjunction with the embodiments of the present application. Obviously, the described embodiments are only a part of embodiments of the present application rather than all of them. Based on the embodiments in the present application, all other embodiments obtained by those skilled in the art without paying a creative work should fall within the scope of the present application.

[0022] An apparatus for directly capturing carbon dioxide from air is provided in the present application, which includes:

a thin-layer moving bed consisting of a filter grating shell and a filter grating inner cylinder with an annular gap formed therebetween and filled therein with spherical solid amine adsorbents;

a high-level tank and multiple induced draft fans that are provided on a top of the thin-layer moving bed, wherein a feeding pipe is provided at a lower part of the high-level tank and is in communication with an upper portion of the annular gap, an air outlet is provided at a top of the high-level tank and is in communication with the filter grating inner cylinder by means of the multiple induced draft fans, and a quick separation connector is provided at an upper portion of the high-level tank;

a conical unloading port provided at a bottom of the thin-layer moving bed;

a desorber provided with a feeding port in communication with the conical unloading port, wherein a heating coil, a CO₂ distribution pipe, and a filter cartridge are provided inside the desorber, a CO₂ outlet is provided at a top of the desorber, and an adsorbent discharging port is provided at a bottom of the desorber; and

a cooler provided with a feeding port in communication with the adsorbent discharging port, wherein a cooling pipe is provided within the cooler, and a top of the cooler is in communication with the quick separation connector of the high-level tank through a riser.

[0023] Referring to FIG. 1, it is a schematic structural view of an apparatus for directly capturing carbon dioxide from air provided in an embodiment of the present application. In FIG. 1, the high-level tank is labelled by 1, the induced draft fan is labelled by 2, the distribution pipe of the high-level tank is labelled by 3, the feeding pipe is labelled by 4, the filter grating inner cylinder is labelled by 5, the filter grating shell is labelled by 6, the thin-layer moving bed is labelled by 7, the discharging pipe is labelled by 8, the screw conveying pipe is labelled by 9, the desorber is labelled by 10, the heating coil is labelled by 11, the CO₂ distribution pipe is labelled by 12, the adsorbent discharging port is labelled by 13, the screw conveying pipe is labelled by 14, the air outlet is labelled by 15, the filter cartridge is labelled by 16, the quick separation connector is labelled by 17, the riser is labelled by 18, the filter cartridge is labelled by 19, the cooler is labelled by 20, the cooling pipe is labelled by 21, and the air distribution pipe is labelled by 22.

[0024] In the present application, the thin-layer moving bed is the main device for capturing carbon dioxide, and includes a filter grating shell and a filter grating inner cylinder. Specially, the filter grating inner cylinder is received in the filter grating shell. In this case, an annular gap is formed between the filter grating shell and the filter grating inner cylinder, and

spherical solid amine adsorbents are filled in the annular gap.

[0025] In the present application, the filter grating shell has a diameter preferably ranging from 2.1m to 10.6m and a filter grating clearance preferably ranging from 30 μ m to 250 μ m. The filter grating inner cylinder has a diameter preferably ranging from 2m to 10m and a filter grating clearance preferably ranging from 30 μ m to 250 μ m. Therefore, the air can free flow while particles of spherical solid amine adsorbent that are placed in the annular gap formed between the filter grating shell and the filter grating inner cylinder are ensured not to leak out through the filter grating clearance.

[0026] In the present application, the annular gap formed between the filter grating shell and the filter grating inner cylinder has a width preferably ranging from 50mm to 300mm.

[0027] In the present application, the spherical solid amine adsorbent is preferably a resin pellet solid amine adsorbent, more preferably a pellet adsorbent (DRC adsorbent) synthesized of polystyrene and solid amine. The particle size of the spherical solid amine adsorbent preferably ranges from 200 μ m to 1000 μ m, more preferably from 300 μ m to 600 μ m. In the present application, the source of the spherical solid amine adsorbent is not specially limited, and the commercially available products known to those skilled in the art can be adopted. In the present application, each kilogram of spherical solid amine adsorbent particles can capture CO₂ of 30g to 60g.

[0028] In the present application, the thin-layer moving bed has a height preferably ranging from 10m to 25m.

[0029] In the present application, a high-level tank and multiple induced draft fans are provided on a top of the thin-layer moving bed. The high-level tank is centrally located at the top of the thin-layer moving bed, and multiple induced draft fans are circumferentially arranged around the high-level tank.

[0030] In the present application, a feeding pipe is provided at a lower part of the high-level tank and is in communication with an upper portion of the annular gap. In this case, the spherical solid amine adsorbent in the high-level tank can enter the annular gap through the feeding pipe. The number of the feeding pipe is not limited, and can be chosen such as to facilitate filling the spherical solid amine adsorbent into the annular gap, as known to those skilled in the art.

[0031] In the present application, an air outlet is provided at a top of the high-level tank and is in communication with the filter grating inner cylinder by means of the multiple induced draft fans, so that the air in the filter grating inner cylinder can be discharged through the air outlet under the action of the multiple induced draft fans. Preferably, the air outlet is provided with a filter cartridge.

[0032] In the present application, a quick separation connector is provided at an upper part of the high-level tank, and is configured to feed the spherical solid amine adsorbent in the riser back into the high-level tank.

[0033] In the present application, a high-level tank distribution pipe is preferably provided in the high-level tank.

[0034] In the present application, a conical unloading port is provided at a bottom of the thin-layer moving bed. The conical unloading port consists of a conical seal head connected to the lower end of the filter grating inner cylinder and a conical funnel connected to the lower end of the filter grating shell. Preferably, a discharging pipe is provided at a bottom of the conical unloading port and is in communication with a feeding port of the desorber through the screw conveying pipe.

[0035] In the present application, it designs a thin-layer moving bed that is movable from top to bottom. The air passes through the thin-layer moving bed in a direction transverse to the thin-layer moving bed to adsorb CO₂. It can capture CO₂ under an ultra-low pressure drop condition of 0.3kPa to 1kPa. An axial flow induced draft fan with a high flow rate and a low wind pressure head can be adopted, which can be used for a large-scale CO₂ capture, thereby reducing the equipment investment and CO₂ capture costs.

[0036] In the present application, the desorber is the main equipment for desorbing the spherical solid amine adsorbent that captures carbon dioxide. A heating coil, a CO₂ distribution pipe, and a filter cartridge are provided inside the desorber. The heating coil is preferably a serpentine steam heating coil. A heat source (e.g., water vapor) enters the heating coil from one end of the heating coil and the condensed water generated after heat exchange is discharged from the other end of the heating coil.

[0037] In the present application, a CO₂ outlet is provided at the top of the desorber, and the CO₂ distribution pipe is preferably in communication with the CO₂ outlet through the filter

cartridge.

[0038] In the present application, an adsorbent discharging port is provided at the bottom of the desorber and is preferably in communication with a feeding port of the cooler through a screw conveying pipe.

5 **[0039]** In the present application, the cooler is the main equipment for cooling the desorbed spherical solid amine adsorbent. A cooling pipe is provided inside the cooler and is preferably a serpentine cooling pipe. Cooling water enters from one end of the cooling pipe and is discharged from the other end of the cooling pipe after heat exchange.

10 **[0040]** In the present application, an air distribution pipe is further provided inside the cooler.

[0041] In the present application, the top of the cooler is in communication with the quick separation connector of the high-level tank through a riser, so that the cooled spherical solid amine adsorbent can be brought back into the high-level tank for recycling.

15 **[0042]** The apparatus provided in the present application as described above realizes a continuous operation in the process of directly capturing CO₂ from the air, with a CO₂ capture rate of 70% to 90%, and can produce CO₂ products with a purity of 95% to 99%. Meanwhile, the apparatus has a compact arrangement and a small occupied area and has no waste solid or liquid discharge.

20 **[0043]** A method for directly capturing carbon dioxide from the air is further provided in the present application, using the apparatus described in the above. The method comprises the following steps:

bringing the air containing CO₂ into the thin-layer moving bed by transversely passing through the filter grating shell so as to be in contact with a spherical solid amine adsorbent for CO₂ adsorption, wherein the purified air after CO₂ capturing transversely pass
25 through the filter grating inner cylinder and is discharged from the air outlet by induced draft fans; moving the CO₂-adsorbed spherical solid amine adsorbent from top to bottom, into the desorber through the conical unloading port, and heating the CO₂-adsorbed spherical solid amine adsorbent by a heating coil so as to desorb CO₂ from the spherical solid amine adsorbent and discharge CO₂ through the CO₂ outlet; and allowing the CO₂-desorbed
30 spherical solid amine adsorbent to enter the cooler for cooling, to pass through the rise to the

high-level tank, and then to be conveyed to the upper part of the annular gap through the feeding pipe for recycling.

[0044] In the present application, the method for directly capturing carbon dioxide from the air includes three processes:

5 **[0045]** (1) Adsorption process: introducing the air into the capture apparatus at a high flow rate by induced draft fans (e.g., a diagonal fan known to those skilled in the art) to be in gas-solid contact with the downward-flowing spherical solid amine adsorbent, which makes the spherical solid amine adsorbent be in fully contact with the air to adsorb carbon dioxide with high efficiency;

10 **[0046]** (2) Desorption process: conveying the absorption-saturated spherical solid amine adsorbent into the desorber to be desorbed by heating;

[0047] (3) Cooling process: further conveying the desorbed spherical solid amine adsorbent into the cooler to be cooled by cooling water, and elevating the cooled spherical solid amine adsorbent to a high level for recycling.

15 **[0048]** In the present application, the air containing CO₂ is preferably the air containing CO₂ of 200ppm to 600ppm, and the source thereof is not limited in the present application. In the present application, after the above adsorption process, the purified air containing CO₂ of 10ppm to 100ppm horizontally passes through the filter grating inner cylinder and is discharged out of the top of the filter grating inner cylinder by induced draft fans.

20 **[0049]** In the present application, the preferred temperature heated by the heating coil ranges from 100°C to 120°C, and the preferred temperature cooled in the cooler ranges from 30°C to 50°C.

[0050] The present application focuses on a large-scale direct air capture operation and formation of a fluidized process capture. With the fluidized bed process, it achieves a
25 scalization process, which significantly reduces investment and capture costs, and achieves an air capture with a high efficiency and a large scale. Meanwhile, a special heat exchange process is adopted, greatly improving energy utilization efficiency. Moreover, an axial flow induced draft fan with a high flow rate and a low wind pressure head can be adopted for large-scale CO₂ capture, which has a broad application prospect.

30 **[0051]** The present application provides an apparatus and a method for directly capturing

carbon dioxide from the air. The apparatus includes: a thin-layer moving bed consisting of a filter grating shell and a filter grating inner cylinder with an annular gap formed therebetween and filled with a spherical solid amine adsorbent; a high-level tank and multiple induced draft fans that are provided on a top of the thin-layer moving bed, wherein a feeding pipe is provided at a lower part of the high-level tank and is in communication with an upper portion of the annular gap, an air outlet is provided at a top of the high-level tank and is in communication with the filter grating inner cylinder by the multiple induced draft fans, and a quick separation connector is provided at an upper portion of the high-level tank; a conical unloading port provided at a bottom of the thin-layer moving bed; a desorber provided with a feeding port in communication with the conical unloading port, wherein a heating coil, a CO₂ distribution pipe, and a filter cartridge are provided inside the desorber, a CO₂ outlet is provided at a top of the desorber, and an adsorbent discharging port is provided at a bottom of the desorber; and a cooler provided with a feeding port in communication with the adsorbent discharging port, wherein a cooling pipe is provided in the cooler, and a top of the cooler is in communication with the quick separation connector of the high-level tank through a riser. Compared with the conventional technology, the apparatus provided in the present application adopts a specific structure and a connection relation and directly capture carbon dioxide from the air using a spherical solid amine thin-layer moving bed, which realizes a carbon dioxide capture with a high efficiency and in a large scale and can continuously produce high-purity carbon dioxide products. Meanwhile, the layout of the apparatus is compact, with a small occupied area, having no waste solid or liquid discharge, which can reduce the equipment investment and carbon dioxide capture costs. The experimental result shows that the apparatus and method for directly capturing carbon dioxide from the air provided in the present application have a CO₂ capture rate of 70% to 90%, and can produce CO₂ products with a purity of 95% to 99%.

[0052] In addition, the present application adopts a special heat exchange process, greatly improving energy utilization efficiency. An axial flow induced draft fan with high flow rate and low wind pressure head can be adopted for the large-scale CO₂ capture, which has broad application prospects.

[0053] In order to further illustrate the present application, a detailed description will be provided below with reference to the following examples.

[0054] Example

[0055] An apparatus for directly capturing carbon dioxide from air as described above is used in the present application. Referring to FIG. 1, the high-level tank is labelled by 1, the diagonal fan is labelled by 2, the distribution pipe of the high-level tank is labelled by 3, the feeding pipes are labelled by 4 (the number of the feeding pipes is twenty), the filter grating inner cylinder is labelled by 5 (having a diameter of 10m and a filter grid clearance of preferably 200 μ m), the filter grating shell is labelled by 6 (having a diameter of 10.2m and a filter grid clearance of preferably 200 μ m), the width of the annular gap formed between the filter grating shell and the filter grating inner cylinder being 100mm, the thin-layer moving bed is labelled by 7 (being 20m in height and filled with the spherical solid amine adsorbent, specifically DRC adsorbent, with a particle size of 300 μ m to 600 μ m), the discharging pipe is labelled by 8, the screw conveying pipe is labelled by 9, the desorber is labelled by 10, the serpentine heating coil is labelled by 11, the CO₂ distribution pipe is labelled by 12, the adsorbent discharging port is labelled by 13, the screw conveying pipe is labelled by 14, the air outlet is labelled by 15, the filter cartridge is labelled by 16, the quick separation connector is labelled by 17, the riser is labelled by 18, the filter cartridge is labelled by 19, the cooler is labelled by 20, the serpentine cooling pipe is labelled by 21, and the air distribution pipe is labelled by 22.

[0056] Referring to FIG. 2, which is a schematic diagram showing a working process of the apparatus for directly capturing carbon dioxide from air as described above, the specific operation process will be described as follow:

[0057] bringing the air containing CO₂ of 400ppm into the thin-layer moving bed by horizontally passing through the filter grating shell under the action of the diagonal fan so as to be in gas-solid contact with a spherical solid amine adsorbent that flows downward for CO₂ adsorption; allowing the purified air (containing CO₂ of 10ppm) after CO₂ capturing to horizontally pass through the filter grating inner cylinder and to be discharged from the air outlet; moving the spherical solid amine adsorbent that has adsorbed CO₂ from top to bottom, into the desorber through the conical unloading port, the discharging pipe and the screw conveying pipe, and heating the spherical solid amine adsorbent to 110°C by the serpentine heating coil (heat-exchanging with a saturation vapor) so as to desorb CO₂ from the spherical solid amine adsorbent and thus to realize the desorption, and discharging CO₂ through the

CO₂ outlet so as to obtain a CO₂ product with a purity of 95% to 99%; enabling the CO₂-desorbed spherical solid amine adsorbent into the cooler through the adsorbent discharging pipe and the screw conveying pipe to be cooled to 40°C (heat-exchanging with a cooling water), and then conveying the spherical solid amine adsorbent into the high-level
5 tank through the riser, and then to the upper part of the annular gap through the feeding pipe for recycling. The CO₂ capture rate of the apparatus for directly capturing carbon dioxide from air reaches 97.5%.

[0058] The description above is only preferred embodiments of the present application. It should be noted for those skilled in the art that improvements and modifications can be made
10 without departing from the concept of the present application but are regarded as falling within the scope of the present application.

CLAIMS

1. An apparatus for directly capturing carbon dioxide from air, comprising:

a thin-layer moving bed, which comprises a filter grating shell and a filter grating inner
5 cylinder, wherein an annular gap is formed between the filter grating shell and the filter
grating inner cylinder, and a spherical solid amine adsorbent is filled in the annular gap;

a high-level tank and a plurality of induced draft fans provided on a top of the thin-layer
moving bed, wherein a feeding pipe is provided at a lower part of the high-level tank and is in
communication with an upper portion of the annular gap, an air outlet is provided at a top of
10 the high-level tank and is in communication with the filter grating inner cylinder by means of
the plurality of multiple induced draft fans, and a quick separation connector is provided at an
upper portion of the high-level tank;

a conical unloading port provided at a bottom of the thin-layer moving bed;

a desorber provided with a feeding port in communication with the conical unloading
15 port, wherein a heating coil, a CO₂ distribution pipe, and a filter cartridge are provided inside
the desorber, a CO₂ outlet is provided at a top of the desorber, and an adsorbent discharging
port is provided at a bottom of the desorber; and

a cooler provided with a feeding port in communication with the adsorbent discharging
port, wherein a cooling pipe is provided in the cooler, and a top of the cooler is in
20 communication with the quick separation connector of the high-level tank through a riser.

2. The apparatus for directly capturing carbon dioxide from air according to claim 1,
wherein

the filter grating shell has a diameter ranging from 2.1m to 10.6m, and a filter grating
25 clearance ranging from 30μm to 250μm,

the filter grating inner cylinder has a diameter ranging from 2m to 10m, and a filter
grating clearance ranging from 30μm to 250μm,

the annular gap formed between the filter grating shell and the filter grating inner
cylinder has a width ranging from 50 mm to 300 mm.

3. The apparatus for directly capturing carbon dioxide from air according to claim 1, wherein the spherical solid amine adsorbent is a resin pellet solid amine adsorbent, and the spherical solid amine adsorbent has a particle size ranging from 200 μ m to 1000 μ m.

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4. The apparatus for directly capturing carbon dioxide from air according to claim 1, wherein the thin-layer moving bed has a height ranging from 10m to 25m.

5. The apparatus for directly capturing carbon dioxide from air according to claim 1, wherein the air outlet is provided with a filter cartridge.

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6. The apparatus for directly capturing carbon dioxide from air according to claim 1, wherein a discharging pipe is provided at a bottom of the conical unloading port and is in communication with the feeding port of the desorber through a screw conveying pipe.

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7. The apparatus for directly capturing carbon dioxide from air according to claim 1, wherein the CO₂ distribution pipe is in communication with the CO₂ outlet through the filter cartridge.

8. The apparatus for directly capturing carbon dioxide from air according to claim 1, wherein the adsorbent discharging port is in communication with the feeding port of the cooler through a screw conveying pipe.

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9. A method for directly capturing carbon dioxide from air by using the apparatus according to any one of claims 1 to 8, wherein the method comprises the steps of:

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bringing an air containing CO₂ into the thin-layer moving bed by transversely passing through the filter grating shell so to be in contact with the spherical solid amine adsorbent for CO₂ adsorption, wherein a purified air after CO₂ capturing transversely passes through the

filter grating inner cylinder and is discharged from the air outlet by means of the induced draft fans;

moving the CO₂-adsorbed spherical solid amine adsorbent from top to bottom, into the desorbtor through the conical unloading port, and heating the CO₂-adsorbed spherical solid amine adsorbent by the heating coil so as to desorb CO₂ from the spherical solid amine adsorbent, wherein the CO₂ is discharged through the CO₂ outlet;

enabling the CO₂-desorbed spherical solid amine adsorbent to enter the cooler to be cooled, and to be elevated to the high-level tank through the riser, and then to be conveyed to the upper part of the annular gap through the feeding pipe for recycling.

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10. The method for directly capturing carbon dioxide from air according to claim 9, wherein a temperature heated by the heating coil is between 110°C and 120°C, and a temperature cooled by the cooler is between 30°C and 50°C.