

DESCRIPTION

TITLE

HUMIDITY-CONTROLLING DEVICE

5

TECHNICAL FIELD

[0001]

The present disclosure relates to a humidity-controlling device.

10 BACKGROUND ART

[0002]

A humidity-controlling device using an adsorbent which adsorbs moisture in the air has been known. Such a humidity-controlling device is used to perform dehumidification by causing the adsorbent to adsorb moisture in the air. The adsorbent which has adsorbed moisture is regenerated by heating, so that the adsorbent can be reused for the dehumidification. Further, such a humidity-controlling device is used to perform also humidification by causing the adsorbent to adsorb moisture in the air, desorbing the moisture from the adsorbent through heating of the adsorbent, and then supplying the moisture desorbed from the adsorbent to air to be humidified.

20 [0003]

In the humidity-controlling device disclosed in Patent Document 1, the adsorbent is carried on the surface of the heat exchanger, and the temperature of the heat exchanger is controlled so that the humidity is in a relative humidity range in which a required adsorption amount can be obtained in the adsorbent.

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CITATION LIST

PATENT DOCUMENT

[0004]

Patent Document 1: Japanese Unexamined Patent Publication No. 2004-294048

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SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005]

However, adsorbents have different adsorption properties (adsorption isotherms) depending on their materials, and such a known humidity-controlling device does not perform heat source control considering the adsorption property for each adsorbent. Thus, energy efficiency has room for improvement.

[0006]

It is an object of the present disclosure to improve energy efficiency of the humidity-controlling device using an adsorbent that adsorbs moisture in the air.

15

SOLUTION TO THE PROBLEM

[0007]

A first aspect of the present disclosure is directed to a humidity-controlling device (10, 110) using an adsorbent which adsorbs moisture in air, the humidity-controlling device (10, 110) including: a control unit (95, 140) configured to control a temperature of the adsorbent or a relative humidity of air supplied to the adsorbent. When, in an adsorption isotherm of the adsorbent, a range less than a first relative humidity value is a first range, a range equal to or higher than the first relative humidity value and equal to or lower than a second relative humidity value (the second relative humidity value > the first relative humidity value) is a

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second range, and a range exceeding the second relative humidity value is a third range, a change in moisture content of the adsorbent to a change in relative humidity in the second range is larger than a change in moisture content of the adsorbent to a change in relative humidity in the first range and the third range. The control unit (95, 140) causes the adsorbent to desorb
5 moisture in a vicinity of the first relative humidity value and cause the adsorbent to adsorb moisture in a vicinity of the second relative humidity value.

[0008]

In the first aspect, the control unit (95, 140) controls a temperature of the adsorbent or a relative humidity of the air supplied to the adsorbent, considering the adsorption property of
10 the adsorbent. This makes it possible to reduce a temperature variation width of the heat source for realizing the relative humidity range in which a required adsorption amount is obtained in the adsorbent, thereby improving energy efficiency.

[0009]

A second aspect of the present disclosure is an embodiment of the first aspect. In the
15 second aspect, a slope of the adsorption isotherm of the adsorbent in the second range is five times or more a slope of the adsorption isotherm of the adsorbent in the first range and the third range.

[0010]

The second aspect allows further improvement in energy efficiency.

20 [0011]

A third aspect of the present disclosure is an embodiment of the first or second aspect. In the third aspect, a variation in moisture content of the adsorbent in the second range is 50% or more of a maximum moisture content of the adsorbent.

[0012]

25 The third aspect allows further improvement in energy efficiency.

[0013]

A fourth aspect of the present disclosure is an embodiment of any one of the first to third aspects. In the fourth aspect, a difference between the second relative humidity value and the first relative humidity value is 40% or less.

5 [0014]

The fourth aspect allows further improvement in energy efficiency.

[0015]

A fifth aspect of the present disclosure is an embodiment of any one of the first to fourth aspects. In the fifth aspect, the vicinity of the first relative humidity value is a range from
10 -10% of the first relative humidity value to the first relative humidity value, and the vicinity of the second relative humidity value is a range from the second relative humidity value to +10% of the second relative humidity value.

[0016]

The fifth aspect allows heat source control in consideration of the adsorption property
15 of the adsorbent, thereby keeping energy efficiency from decreasing.

[0017]

A sixth aspect of the present disclosure is an embodiment of any one of the first to fifth aspects. In the sixth aspect, the adsorbent has a metal organic framework.

[0018]

20 The sixth aspect allows an adsorbent having desired adsorption property to be obtained.

[0019]

A seventh aspect of the present disclosure is an embodiment of any one of the first to sixth aspects. In the seventh aspect, the humidity-controlling device further includes: an adsorption desorption unit (81, 82, 115A, 115B) including the adsorbent and configured to
25 adsorb moisture in target air and desorb the moisture adsorbed; a heat source (51, 52, 123, 133)

configured to control a relative humidity at which the adsorption desorption unit (81, 82, 115A, 115B) adsorbs and desorbs moisture; a fan (25, 26, 124, 134) configured to control airflow of the target air; and an acquisition unit (91, 92, 93, 94, 121, 131) configured to acquire temperature-humidity data of the target air. The control unit (95, 140) controls a temperature of the heat source (51, 52, 123, 133) based on the temperature-humidity data acquired by the acquisition unit (91, 92, 93, 94, 121, 131).

[0020]

The seventh aspect allows temperature control of the heat source to achieve a relative humidity range in which a required adsorption amount is obtained in the adsorbent.

10 [0021]

An eighth aspect of the present disclosure is an embodiment of the seventh aspect. In the eighth aspect, the adsorption isotherm of the adsorbent includes an adsorption line when moisture is adsorbed, and a desorption line when adsorbed moisture is desorbed, the adsorption desorption unit (81, 82, 115A, 115B) includes: an adsorption unit (81, 82, 115A, 115B) configured to adsorb moisture in the target air; and a desorption unit (81, 82, 115A, 115B) configured to desorb moisture adsorbed, the heat source (51, 52, 123, 133) includes a first heat source (51, 52, 123, 133) configured to control a relative humidity at which the adsorption unit (81, 82, 115A, 115B) adsorbs moisture; and a second heat source (51, 52, 123, 133) configured to control a relative humidity at which the desorption unit (81, 82, 115A, 115B) desorbs moisture, the control unit (95, 140) controls a temperature of the second heat source (51, 52, 123, 133) such that moisture is desorbed from the desorption unit (81, 82, 115A, 115B) in the vicinity of the first relative humidity value in the desorption line, and controls a temperature of the first heat source (51, 52, 123, 133) such that the adsorption unit (81, 82, 115A, 115B) adsorbs moisture in the vicinity of the second relative humidity value in the adsorption line.

25 [0022]

The eighth aspect allows moisture to be desorbed from the adsorbent in the desorption unit (81, 82, 115A, 115B) in the vicinity of the first relative humidity value, and allows the adsorbent in the adsorption unit (81, 82, 115A, 115B) to adsorb moisture in the vicinity of the second relative humidity value.

5 [0023]

A ninth aspect of the present disclosure is an embodiment of the eighth aspect. In the ninth aspect, when a room is dehumidified, based on temperature-humidity data of first target air supplied into the room from outside and a second target air exhausted out of the room from inside, the control unit (95, 140) performs control to lower a temperature of the first heat source
10 (51, 52, 123, 133) such that a relative humidity of the first target air reaching the adsorption unit (81, 82, 115A, 115B) has a value in the vicinity of the second relative humidity value in the adsorption line, and to increase a temperature of the second heat source (51, 52, 123, 133) such that a relative humidity of the second target air reaching the desorption unit (81, 82, 115A, 115B) has a value in the vicinity of the first relative humidity value in the desorption line,
15 thereby supplying the first target air into the room as dehumidified air and making the second target air into high-humidity air to be exhaust out of the room.

[0024]

In the ninth aspect, energy efficiency in the dehumidification of the room is improved.

[0025]

20 A tenth aspect of the present disclosure is an embodiment of the eighth or ninth aspect. In the tenth aspect, when a room is humidified, based on temperature-humidity data of the first target air exhausted out of the room from inside and the second target air supplied into the room from outside, the control unit (95, 140) increases a temperature of the second heat source (51, 52, 123, 133) such that a relative humidity of the second target air reaching the desorption unit
25 (81, 82, 115A, 115B) has a value in the vicinity of the first relative humidity value in the

desorption line, and lowers a temperature of the first heat source (51, 52, 123, 133) such that a relative humidity of the first target air reaching the adsorption unit (81, 82, 115A, 115B) has a value in the vicinity of the second relative humidity value in the adsorption line, thereby supplying the second target air into the room as humidified air and making the first target air
5 into low-humidity air to be exhausted out of the room.

[0026]

In the tenth aspect, energy efficiency in humidification of the room is improved.

[0027]

An eleventh aspect of the present disclosure is an embodiment of any one of the eighth
10 to tenth aspects. In the eleventh aspect, the first heat source (51, 52) and the second heat source (51, 52) constitute a heat pump, and the control unit (95) controls a temperature of the first heat source (51, 52) and a temperature of the second heat source (51, 52) in a coordinated manner.

[0028]

The eleventh aspect allows further improvement in energy efficiency.

15 [0029]

A twelfth aspect of the present disclosure is an embodiment of any one of the eighth
to tenth aspects. In the twelfth aspect, the first heat source (123, 133) and the second heat source (123, 133) do not constitute a heat pump, and the control unit (140) independently controls a temperature of the first heat source (123, 133) and a temperature of the second heat source (123,
20 133).

[0030]

The twelfth aspect allows simplification of the humidity-controlling device (110).

BRIEF DESCRIPTION OF THE DRAWINGS

25 [0031]

FIG. 1 is a diagram illustrating an adsorption property of an adsorbent used in a humidity-controlling device according to an embodiment.

FIG. 2 is a diagram illustrating an adsorption property of an adsorbent of Comparative Example.

5 FIG. 3 is a schematic cross-sectional view of a building in a state in which a humidity-controlling device according to a first embodiment is installed.

FIG. 4 shows a plan view, a right-side view, and a left-side view of a schematic configuration of the humidity-controlling device according to the first embodiment.

FIGS. 5A and 5B are piping system diagrams illustrating a refrigerant circuit of the
10 humidity-controlling device according to the first embodiment. FIG. 5A illustrates a flow of a refrigerant under a first action, and FIG. 5B illustrates a flow of the refrigerant under a second action.

FIG. 6 is a block diagram illustrating a configuration of a control unit of the humidity-controlling device according to the first embodiment.

15 FIG. 7 shows a plan view, a right-side view, and a left-side view of schematic flow of air under the first action of a dehumidifying operation in the humidity-controlling device according to the first embodiment.

FIG. 8 shows a plan view, a right-side view, and a left-side view of schematic flow of air under a second action of a dehumidifying operation in the humidity-controlling device
20 according to the first embodiment.

FIG. 9 shows a plan view, a right-side view, and a left-side view of schematic flow of air under a first action of a humidifying operation in the humidity-controlling device according to the first embodiment.

FIG. 10 shows a plan view, a right-side view, and a left-side view of schematic flow of
25 air under the second action of the humidifying operation in the humidity-controlling device

according to the first embodiment.

FIG. 11 shows a plan view, a right-side view, and a left-side view of schematic flow of air under the first action of a ventilating operation in the humidity-controlling device according to the first embodiment.

5 FIG. 12 shows a plan view, a right-side view, and a left-side view of schematic flow of air under the second action of the ventilating operation in the humidity-controlling device according to the first embodiment.

FIG. 13 is a flowchart illustrating a process of controlling the humidity-controlling device according to the first embodiment.

10 FIG. 14 is a schematic configuration diagram of a humidity-controlling device according to a second embodiment.

FIG. 15 is a flowchart illustrating a process of controlling the humidity-controlling device according to the second embodiment.

15 DESCRIPTION OF EMBODIMENTS

[0032]

Embodiments of the present disclosure will be described below with reference to the accompanying drawings. The embodiments below are merely exemplary ones in nature, and are not intended to limit the scope, applications, or use of the invention.

20 [0033]

(First Embodiment)

A humidity-controlling device (10) according to the first embodiment performs dehumidification or humidification in a target space by using an adsorbent which adsorbs moisture in the air. The humidity-controlling device (10) controls a temperature of the adsorbent
25 or a relative humidity of the air supplied to the adsorbent, considering the adsorption property

of the adsorbent.

[0034]

<Adsorbent>

The adsorbent used in the humidity-controlling device (10) according to this
5 embodiment has a so-called S-shaped adsorption property (adsorption isotherm) as shown in
FIG. 1, for example. The adsorption isotherm shown in FIG. 1 includes an adsorption line when
moisture is adsorbed, and a desorption line when adsorbed moisture is desorbed.

[0035]

When, in an adsorption isotherm illustrated in FIG. 1, a range less than a first relative
10 humidity value (RH1) is a first range (I), a range equal to or higher than the first relative
humidity value (RH1) and equal to or lower than a second relative humidity value (RH2) ($RH2 > RH1$) is a second range (II), and a range exceeding the second relative humidity value (RH2)
is a third range (III), a change in moisture content of the adsorbent to a change in relative
humidity in the second range (II) is larger than a change in moisture content of the adsorbent to
15 a change in relative humidity in the first range (I) and the third range (III). The “moisture
content” (unit: g/g) means a mass of water which can be contained in 1 g of the adsorbent.

[0036]

The humidity-controlling device (10) according to this embodiment causes the
adsorbent to desorb moisture in the vicinity of the first relative humidity value (RH1), for
20 example, in the range of $(RH1 - 10\%)$ to $(RH1)$, preferably in the range of $(RH1 - 5\%)$ to
 $(RH1)$, more preferably in the range of $(RH1 - 3\%)$ to $(RH1)$.

[0037]

The humidity-controlling device (10) according to this embodiment causes the
adsorbent to adsorb moisture in the vicinity of the second relative humidity value (RH2), for
25 example, in the range of $(RH2)$ to $(RH2 + 10\%)$, preferably in the range of $(RH2)$ to $(RH2 +$

5%), more preferably in the range of (RH2) to (RH2 + 3%).

[0038]

In the adsorbent used in the humidity-controlling device (10) according to this embodiment, the slope of the adsorption isotherm in the second range (II) is preferably five
5 times or more the slope of the adsorption isotherm in each of the first range (I) and the third range (III).

[0039]

In the adsorbent used in the humidity-controlling device (10) according to this embodiment, a variation ΔW in the moisture content in the second range (II) is preferably 50%
10 or more of the maximum moisture content of the adsorbent. The variation ΔW in the moisture content in the second range (II) is preferably 0.3 g or more.

[0040]

In the adsorbent used in the humidity-controlling device (10) according to this embodiment, the difference between the second relative humidity value (RH2) and the first
15 relative humidity value (RH1) is preferably 40% or less.

[0041]

As described above, by using the adsorbent having an S-shaped adsorption property, the relative humidity range in which the adsorption and desorption (regeneration) of the moisture in the adsorbent are performed is narrowed. This makes it possible to narrow the
20 temperature variation width of the heat source required to achieve the relative humidity range, thereby improving energy efficiency.

[0042]

In contrast, for example, when an adsorbent of Comparative Example having a linear adsorption property as shown in FIG. 2 is used, a relative humidity range ΔRH (the lower limit
25 RH1' to the upper limit RH2') in which a required variation ΔW in moisture content is obtained

is wide, so that the required heat source temperature variation width becomes large, thereby deteriorating energy efficiency.

[0043]

The adsorbent used in the humidity-controlling device (10) according to this embodiment is not particularly limited as long as it has an S-shaped adsorption property as shown in FIG. 1, but if the adsorbent is made of, for example, a metal organic framework (MOF) or mesoporous silica carrying metal nanoparticles, it is easier to achieve desired adsorption property.

[0044]

<Configuration of Humidity-Controlling Device>

The humidity-controlling device (10) according to this embodiment performs humidity control of an indoor space (200) and ventilation of the indoor space (200), as illustrated in FIG. 3. The humidity-controlling device (10) controls the humidity of sucked outdoor air (OA) and supplies the air into the indoor space (200), while exhausting sucked room air (RA) to an outdoor space (201).

[0045]

The humidity-controlling device (10) may be installed in a building together with an air conditioner (150), as illustrated in FIG. 3. The air conditioner (150) includes an outdoor unit (152) and an indoor unit (151) and selectively performs a cooling operation and a heating operation. The humidity-controlling device (10) is connected to the indoor space (200) into which the indoor unit (151) of the air conditioner (150) blows air, via ducts (102, 103). Specifically, the humidity-controlling device (10) is connected to the indoor space (200) via the air supply duct (102) and the indoor air suction duct (103), and is connected to the outdoor space (201) via an exhaust duct (101) and an outdoor air suction duct (104).

[0046]

The humidity-controlling device (10) will be described in detail below with reference to FIG. 4. Unless otherwise specified, the terms in the following description which indicate directions, such as “upper,” “top,” “lower,” “bottom,” “right,” “left,” “front,” and “rear,” refer to the directions when the humidity-controlling device (10) is viewed from the front.

5 [0047]

The humidity-controlling device (10) includes a casing (11). The casing (11) houses a refrigerant circuit (50) to be described later. The refrigerant circuit (50) is connected to a first adsorption heat exchanger (51), a second adsorption heat exchanger (52), a compressor (53), a four-way switching valve (54), and an electrically powered expansion valve (55). The
10 refrigerant circuit (50) constitutes a heat pump.

[0048]

The casing (11) has a rectangular parallelepiped and slightly flattened shape with a relatively short height. The casing (11) includes an outdoor air inlet (24), an indoor air inlet (23), an air supply port (22), and an exhaust port (21). The outdoor air inlet (24) is connected
15 with the outdoor air suction duct (104), the indoor air inlet (23) is connected with the indoor air suction duct (103), the air supply port (22) is connected with the air supply duct (102), and the exhaust port (21) is connected with the exhaust duct (101).

[0049]

The outdoor air inlet (24) and the indoor air inlet (23) are provided on a back panel
20 portion (13) of the casing (11). The outdoor air inlet (24) is provided on a lower portion of the back panel portion (13). The indoor air inlet (23) is provided on an upper portion of the back panel portion (13). The air supply port (22) is provided on a first side panel portion (14) of the casing (11). On the first side panel portion (14), the air supply port (22) is provided in the vicinity of an edge associated with a front panel portion (12) of the casing (11). The exhaust
25 port (21) is provided on a second side panel portion (15) of the casing (11). On the second side

panel portion (15), the exhaust port (21) is provided in the vicinity of an edge associated with the front panel portion (12).

[0050]

5 An upstream partition plate (71), a downstream partition plate (72), and a center partition plate (73) are provided in an internal space of the casing (11). These partition plates (71 to 73) are provided to stand on a bottom plate of the casing (11) so as to partition the internal space of the casing (11), extending from the bottom plate to a top panel of the casing (11).

[0051]

10 The upstream partition plate (71) and the downstream partition plate (72) are provided with a predetermined interval in a front-to-back direction of the casing (11) parallel with the front panel portion (12) and the back panel portion (13). The upstream partition plate (71) is closer to the back panel portion (13) than to the front panel portion (12). The downstream partition plate (72) is closer to the front panel portion (12) than to the back panel portion (13). The arrangement of the center partition plate (73) will be described later.

15 [0052]

Inside the casing (11), a space between the upstream partition plate (71) and the back panel portion (13) is partitioned into two spaces, one of which is above the other, and the upper one of the spaces constitutes an indoor air path (32) and the lower one of the spaces constitutes an outdoor air path (34). The indoor air path (32) is in communication with the indoor space (200) via the duct connected with the indoor air inlet (23). The outdoor air path (34) is in communication with the outdoor space (201) via the duct connected with the outdoor air inlet (24).

[0053]

25 The indoor air path (32) is provided with an indoor air filter (27), an indoor air temperature sensor (91), and an indoor air humidity sensor (92). The indoor air filter (27) is for

removing dust particles and the like from the air passing therethrough. The indoor air temperature sensor (91) is configured to measure a temperature of the indoor air flowing through the indoor air path (32). The indoor air humidity sensor (92) is configured to measure a relative humidity of the indoor air flowing through the indoor air path (32).

5 [0054]

The outdoor air path (34) is provided with an outdoor air filter (28), an outdoor air temperature sensor (93), and an outdoor air humidity sensor (94). The outdoor air filter (28) is for removing dust particles and the like from the air passing therethrough. The outdoor air temperature sensor (93) is configured to measure a temperature of the outdoor air flowing
10 through the outdoor air path (34). The outdoor air humidity sensor (94) is configured to measure a relative humidity of the outdoor air flowing through the outdoor air path (34).

[0055]

The indoor air temperature sensor (91), the indoor air humidity sensor (92), the outdoor air temperature sensor (93), and the outdoor air humidity sensor (94) constitute an acquisition
15 unit configured to acquire temperature-humidity data of target air. Note that the indoor air temperature sensor (91), the indoor air humidity sensor (92), the outdoor air temperature sensor (93), and the outdoor air humidity sensor (94) are not illustrated in FIGS. 7 to 12 referred later.

[0056]

Inside the casing (11), a space between the upstream partition plate (71) and the
20 downstream partition plate (72) is partitioned into left and right spaces with the center partition plate (73). The space on the right side of the center partition plate (73) constitutes a first heat exchanger compartment (37), and the space on the left side of the center partition plate (73) constitutes a second heat exchanger compartment (38). In the first heat exchanger compartment (37), a first adsorption heat exchanger (51) which serves as an adsorption desorption unit (an
25 adsorption unit or a desorption unit) (81) is housed. In the second heat exchanger compartment

(38), a second adsorption heat exchanger (52) which serves as an adsorption desorption unit (an adsorption unit or a desorption unit) (82) is housed. In the first heat exchanger compartment (37), the electrically powered expansion valve (55) (see FIGS. 5A and 5B) of the refrigerant circuit (50) is housed.

5 [0057]

The adsorption desorption units (81, 82) are so-called cross-fin-type fin-and-tube heat exchangers with the adsorbent carried on a surface thereof. The adsorption desorption units (81, 82) adsorb moisture in the target air and desorb the moisture adsorbed. The adsorption heat exchangers (51, 52) each function as a heat source (a first heat source or a second heat source) configured to control a relative humidity at which each adsorption desorption unit (81, 82) performs adsorption and desorption of moisture.

[0058]

The adsorption heat exchangers (51, 52) each may have a rectangular thick plate-like shape or a rectangular parallelepiped flattened shape, as a whole. The adsorption heat exchangers (51, 52) may be each provided to stand inside the heat exchanger compartment (37, 38) such that the front and back sides of the adsorption heat exchanger (51, 52) are parallel with the upstream partition plate (71) and the downstream partition plate (72).

[0059]

In the internal space of the casing (11), a space along a front surface of the downstream partition plate (72) is partitioned into upper and lower spaces. Of these upper and lower spaces, the upper space constitutes the air supply path (31), and the lower space constitutes the exhaust path (33).

[0060]

The upstream partition plate (71) is provided with four dampers (41) to (44), which are openable. The dampers (41) to (44) are substantially rectangular in shape with a width longer

than a height. Specifically, of the upstream partition plate (71), a portion facing the indoor air path (32) (an upper portion) is provided with a first indoor air damper (41) on the right side of the center partition plate (73) and a second indoor air damper (42) on the left side of the center partition plate (73). Further, of the upstream partition plate (71), a portion facing the outdoor
5 air path (34) (a lower portion) is provided with a first outdoor air damper (43) on the right side of the center partition plate (73) and a second outdoor air damper (44) on the left side of the center partition plate (73). The four dampers (41) to (44) provided to the upstream partition plate (71) constitute a switching mechanism (40) for switching over air flow paths.

[0061]

10 The downstream partition plate (72) is provided with four dampers (45) to (48), which are openable. The dampers (45) to (48) are substantially rectangular in shape with a width longer than a height. Specifically, of the downstream partition plate (72), a portion facing the air supply path (31) (an upper portion) is provided with a first air supply-side damper (45) on the right side of the center partition plate (73) and a second air supply-side damper (46) on the
15 left side of the center partition plate (73). Further, of the downstream partition plate (72), a portion facing the exhaust path (33) (a lower portion) is provided with a first exhaust-side damper (47) on the right side of the center partition plate (73) and a second exhaust-side damper (48) on the left side of the center partition plate (73). The four dampers (45) to (48) provided to the downstream partition plate (72) constitute a switching mechanism (40) for switching over
20 air flow paths.

[0062]

In the casing (11), a space between the front panel portion (12) and the air supply path (31) and exhaust path (33) is partitioned into left and right spaces with a partition plate (77). The space on the right side of the partition plate (77) constitutes an air supply fan compartment
25 (36), and a space on the left side of the partition plate (77) constitutes an exhaust fan

compartment (35).

[0063]

The air supply fan compartment (36) houses an air supply fan (26) therein. The exhaust fan compartment (35) houses an exhaust fan (25) therein. The air supply fan (26) and the exhaust fan (25) are centrifugal multiblade fans (so-called sirocco fans). The air supply fan (26) is configured to blow out, to the air supply port (22), the air sucked in from beyond the downstream partition plate (72). The exhaust fan (25) is configured to blow out, to the exhaust port (21), the air sucked in from beyond the downstream partition plate (72).

[0064]

The air supply fan compartment (36) houses the compressor (53) and the four-way switching valve (54) of the refrigerant circuit (50) (see FIGS. 5A and 5B). The compressor (53) and the four-way switching valve (54) are disposed between the air supply fan (26) and the partition plate (77) in the air supply fan compartment (36).

[0065]

In addition, the humidity-controlling device (10) according to this embodiment is further provided with a ventilation path (85) connecting an outdoor air path (34) and an air supply fan compartment (36). The ventilation path (85) is opened and closed by a first ventilation damper (86) on the outdoor air inlet (24) side and a second ventilation damper (87) on the air supply port (22) side. On the front panel portion (12) side of the casing (11), an electric component box (88) including a control board on which the controller (control unit) (95) to be described later is provided, power supply board, and other components provided. Note that, in each of FIG. 4 and FIGS. 7 to 12 described later, the ventilation path (85), the dampers (86) and (87), and the electric component box (88) are shown only in plan view for the sake of simplicity.

[0066]

<Configuration of Refrigerant Circuit>

As illustrated in FIGS. 5A and 5B, the refrigerant circuit (50) is a closed circuit including the first adsorption heat exchanger (51), the second adsorption heat exchanger (52), the compressor (53), the four-way switching valve (54), and the electrically powered expansion valve (55). The refrigerant circuit (50) circulates therethrough a refrigerant filled therein, so as to perform a vapor compression refrigeration cycle. Although not illustrated, a plurality of temperature sensors and pressure sensors are attached to the refrigerant circuit (50).

[0067]

In the refrigerant circuit (50), a discharge pipe of the compressor (53) is connected to a first port of the four-way switching valve (54), and a suction pipe of the compressor (53) is connected to a second port of the four-way switching valve (54). Moreover, the refrigerant circuit (50) is configured such that the first adsorption heat exchanger (51), the electrically powered expansion valve (55), and the second adsorption heat exchanger (52) are arranged in this order from a third port to a fourth port of the four-way switching valve (54).

[0068]

The four-way switching valve (54) is configured to be switchable between a first state (a state illustrated in FIG. 5A) in which the first and third ports are in communication with each other and the second and fourth ports are in communication with each other, and a second state (a state illustrated in FIG. 5B) in which the first and fourth ports are in communication with each other and the second and third ports are in communication with each other.

[0069]

The compressor (53) is a hermetic compressor including a compression mechanism and an electric motor for driving the compression mechanism, which are housed in the same casing. The electric motor for the compressor (53) is supplied with an alternating current via an inverter. When an output frequency of the inverter (i.e., an operation frequency of the

compressor (53)) is changed, rotational speeds of the electric motor and the compression mechanism driven by the electric motor change, and as a result, an operating capacity of the compressor (53) changes. An increase in the rotational speed of the compression mechanism increases the operating capacity of the compressor (53), and a decrease in the rotational speed of the compression mechanism decreases the operating capacity of the compressor (53).

[0070]

<Configuration of Controller>

The humidity-controlling device (10) is provided with a controller (control unit) (95) as illustrated in FIG. 6. The controller (95) may include, e.g., a microcomputer and a memory device that stores software for operating the microcomputer. Measured values by the indoor air humidity sensor (92), the indoor air temperature sensor (91), the outdoor air humidity sensor (94), and the outdoor air temperature sensor (93) are inputted to the controller (95). Measured values by the temperature sensors and the pressure sensors provided for the refrigerant circuit (50) are inputted to the controller (95). Signals indicative of an operating state of the air conditioner (150) (for example, a signal indicating whether or not the air conditioner (150) is in operation, a signal indicating whether the operation of the air conditioner (150) is a cooling operation or a heating operation) are inputted to the controller (95). The controller (95) performs operation control of the humidity-controlling device (10) based on these measured values and signals inputted. In other words, the controller (95) controls the operations of the dampers (41) to (48), (86), and (87), the fans (25) and (26), the compressor (53), the electrically powered expansion valve (55), and the four-way switching valve (54).

[0071]

As illustrated in FIG. 6, the controller (95) includes a compressor control portion (96) and an operating mode determination portion (97). The compressor control portion (96) sets a target value of the operation frequency of the compressor (53) based on the measured values by

the sensors (91) to (94) and the like. The operating mode determination portion (97) selects an operation to be carried out by the humidity-controlling device (10) based on the measured values by the sensors (91) to (94), the signals indicative of the operating state of the air conditioner (150), and the like.

5 [0072]

The controller (95) controls a temperature of the adsorbent carried on each adsorption desorption unit (81, 82) or a relative humidity of the air supplied to the adsorbent. Specifically, the controller (95) controls a temperature of each adsorption desorption unit (81, 82), i.e., each adsorption heat exchanger (51, 52) based on temperature-humidity data acquired by the indoor
10 air humidity sensor (92), indoor air temperature sensor (91), outdoor air humidity sensor (94), and outdoor air temperature sensor (93), and causes the adsorbent to desorb moisture in the vicinity of the first relative humidity value (RH1) and causes the adsorbent to adsorb moisture in the vicinity of the second relative humidity value (RH2).

[0073]

15 When the first adsorption heat exchanger (51) and the second adsorption heat exchanger (52) constitute a heat pump, the controller (95) controls the temperatures of the first adsorption heat exchanger (51) and the second adsorption heat exchanger (52) in a coordinated manner.

[0074]

20 <Operation>

The humidity-controlling device (10) according to this embodiment selectively performs the dehumidifying operation, the humidifying operation, the cooling operation, the heating operation, and ventilating operation. The dehumidifying operation and the humidifying operation are humidity controlling operations for controlling the absolute humidity of the
25 outdoor air to be supplied to the indoor space (200). In other words, the dehumidifying

operation and the humidifying operation are operations for treating mainly latent heat load (dehumidification load or humidification load) of the indoor space (200). The cooling operation and the heating operation are sensible heat-treating operations for controlling the temperature of the outdoor air to be supplied to the indoor space (200). In other words, the cooling operation and the heating operation are operations for treating mainly sensible heat load (cooling load or heating load) of the indoor space (200). The ventilating operation is an operation simply for ventilating the indoor space (200).

[0075]

For each of the dehumidifying operation, the humidifying operation, the cooling operation, the heating operation, and the ventilating operation, the air supply fan (26) and the exhaust fan (25) operate, and operations of the four-way switching valve (54) and the dampers (41) to (48), (86), and (87) are switched at a predetermined timing at regular time intervals. The humidity-controlling device (10) supplies outdoor air (OA) sucked therein to the indoor space (200) as the supply air (SA), and exhaust room air (RA) sucked therein to the outdoor space (201) as the exhaust air (EA).

[0076]

When the adsorption isotherm of the adsorbent used in the humidity-controlling device (10) includes an adsorption line when moisture is adsorbed, and a desorption line when adsorbed moisture is desorbed, as illustrated in FIG. 1, the controller (95) may control a temperature of the adsorption heat exchanger (51, 52) such that moisture is desorbed from the desorption unit (81, 82) in the vicinity of the first relative humidity value (RH1) in the desorption line, and control a temperature of the adsorption heat exchanger (51, 52) such that the adsorption unit (81, 82) adsorbs moisture in the vicinity of the second relative humidity value (RH2) in the adsorption line.

[0077]

Hereinafter, the dehumidifying operation, the humidifying operation, and the ventilating operation performed by the humidity-controlling device (10) will be described in detail.

[0078]

5 [Dehumidifying Operation]

Under the dehumidifying operation, the humidity-controlling device (10) sucks, as first target air, the outdoor air through the outdoor air inlet (24) into the casing (11), and sucks, as second target air, the indoor air through the indoor air inlet (23) into the casing (11). In the refrigerant circuit (50), the compressor (53) operates, and an opening degree of the electrically
10 powered expansion valve (55) is controlled. Under the dehumidifying operation, the humidity-controlling device (10) repeats the first and second actions to be described later each for, e.g., 3 min, alternatively. In other words, the dehumidifying operation is such that a first predetermined period, which is a time period for which the first or second action is continued, is 3 min.

15 [0079]

In the first action of the dehumidifying operation shown in FIG. 7, the second adsorption heat exchanger (52) operates as an evaporator, and the adsorption desorption unit (adsorption unit) (82) adsorbs moisture in first target air (OA), and the dehumidified air (SA) is supplied into the room. The first adsorption heat exchanger (51) operates as a condenser,
20 moisture desorbed from the adsorption desorption unit (desorption unit) (81) is added to the second target air (RA), and the high-humidity air (EA) is exhausted out of the room.

[0080]

In the second action of the dehumidifying operation shown in FIG. 8, the four-way switching valve (54) and the dampers (41) to (48) switch flow paths of the air, the first
25 adsorption heat exchanger (51) operates as an evaporator, and the adsorption desorption unit

(adsorption unit) (81) adsorbs moisture in the first target air (OA), and the dehumidified air (SA) is supplied into the room. Further, the second adsorption heat exchanger (52) operates as a condenser, moisture desorbed from the adsorption desorption unit (desorption unit) (82) is added to the second target air (RA), and the high-humidity air (EA) is exhausted out of the room.

5 [0081]

For details, as illustrated in FIG. 7, the switching mechanism (40) sets a flow path of the air to a second path in the first action of the dehumidifying operation. Specifically, the first indoor air damper (41), the second outdoor air damper (44), the second air supply-side damper (46), and the first exhaust-side damper (47) are open, and the second indoor air damper (42),
10 the first outdoor air damper (43), the first air supply-side damper (45), and the second exhaust-side damper (48) are closed. During the first action, the four-way switching valve (54) is in the first state (the state illustrated in FIG. 5A). The refrigerant circuit (50) performs the refrigeration cycle, in which the first adsorption heat exchanger (51) functions as a condenser (a radiator), and the second adsorption heat exchanger (52) functions as an evaporator.

15 [0082]

The first target air (OA) flowing into the outdoor air path (34) flows into the second heat exchanger compartment (38) through the second outdoor air damper (44), and thereafter passes through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (first heat source) (52), i.e., the adsorption desorption unit (adsorption unit) (82), the
20 moisture in the first target air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The temperature of the first target air is lowered to some extent in the second adsorption heat exchanger (52). The first target air thus dehumidified by the adsorption unit (82) flows into the air supply path (31) through the second air supply-side damper (46), and the first target air (SA) after passing the air supply fan
25 compartment (36) is supplied to the indoor space (200) through the air supply port (22).

[0083]

On the other hand, the second target air (RA) flowing into the indoor air path (32) flows into the first heat exchanger compartment (37) through the first indoor air damper (41), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption
5 heat exchanger (second heat source) (51), i.e., the adsorption desorption unit (desorption unit) (81), the moisture is desorbed from the adsorbent heated by the refrigerant, and the moisture thus desorbed is added to the second target air. The second target air humidified by the desorption unit (81) flows into an exhaust path (33) through the first exhaust-side damper (47), and the second target air (EA) after passing through the exhaust fan compartment (35) is
10 exhausted to the outdoor space (201) through the exhaust port (21).

[0084]

As illustrated in FIG. 8, the switching mechanism (40) sets the flow path of the air to a first path in a second action of the dehumidifying operation. Specifically, the second indoor air damper (42), the first outdoor air damper (43), the first air supply-side damper (45), and the
15 second exhaust-side damper (48) are open, and the first indoor air damper (41), the second outdoor air damper (44), the second air supply-side damper (46), and the first exhaust-side damper (47) are closed. During the second action, the four-way switching valve (54) is in the second state (the state illustrated in FIG. 5B). The refrigerant circuit (50) performs the refrigeration cycle, in which the second adsorption heat exchanger (52) functions as a condenser
20 (a radiator), and the first adsorption heat exchanger (51) functions as an evaporator.

[0085]

The first target air (OA) flowing into the outdoor air path (34) flows into the first heat exchanger compartment (37) through the first outdoor air damper (43), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption heat exchanger (first
25 heat source) (51), i.e., the adsorption desorption unit (adsorption unit) (81), the moisture in the

first target air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The temperature of the first target air is lowered to some extent in the first adsorption heat exchanger (51). The first target air thus dehumidified by the adsorption unit (81) flows into the air supply path (31) via the first air supply-side damper (45),
5 and the first target air (SA) after passing through the air supply fan compartment (36) is supplied to the indoor space (200) through the air supply port (22).

[0086]

On the other hand, the second target air (RA) flowing into the indoor air path (32) flows into the second heat exchanger compartment (38) through the second indoor air damper
10 (42), and thereafter passes through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (second heat source) (52), i.e., the adsorption desorption unit (desorption unit) (82), the moisture is desorbed from the adsorbent heated by the refrigerant, and the moisture thus desorbed is added to the second target air. The second target air humidified by the desorption unit (82) flows into an exhaust path (33) through the second
15 exhaust-side damper (48), and the second target air (EA) after passing through the exhaust fan compartment (35) is exhausted to the outdoor space (201) via the exhaust port (21).

[0087]

In the dehumidifying operation described above, based on temperature-humidity data (measured values by the sensors (91 to 94)) of the first target air supplied into the room from
20 outside and the second target air exhausted out of the room from inside, the controller (95) may lower a temperature of the adsorption heat exchanger (51, 52) such that a relative humidity of the first target air reaching the adsorption unit (81, 82) has a value in the vicinity of the second relative humidity value (RH2) in the adsorption line, and increase a temperature of the adsorption heat exchangers (51, 52) such that the relative humidity of the second target air
25 reaching the desorption unit (81, 82) has a value in the vicinity of the first relative humidity

value (RH1) in the desorption line. This allows, while improving energy efficiency, the first target air (OA) to be supplied into the room as dehumidified air (SA), and the second target air (RA) to be made into high-humidity air (EA) to be exhausted out of the room.

[0088]

5 [Humidifying Operation]

Under the humidifying operation, the humidity-controlling device (10) sucks, as second target air, the outdoor air through the outdoor air inlet (24) into the casing (11), and sucks, as first target air, the indoor air through the indoor air inlet (23) into the casing (11). In the refrigerant circuit (50), the compressor (53) operates, and an opening degree of the electrically powered expansion valve (55) is controlled. Under the humidifying operation, the humidity-controlling device (10) repeats the first and second actions to be described later each for 3 min 30 sec, alternatively. In other words, the humidifying operation is such that a first predetermined period, which is a time period for which the first or second action is continued, is 3 min 30 sec.

15 [0089]

In the first action of the humidifying operation shown in FIG. 9, the first adsorption heat exchanger (51) operates as a condenser, the moisture desorbed from the adsorption desorption unit (desorption unit) (81) is added to the second target air (OA), and the humidified air (SA) is supplied into the room. The second adsorption heat exchanger (52) operates as an evaporator, and the adsorption desorption unit (adsorption unit) (82) adsorbs moisture in the first target air (RA) and the dehumidified air (EA) is exhausted out of the room.

[0090]

In the second action of the humidifying operation shown in FIG. 10, the four-way switching valve (54) and the dampers (41) to (48) switch flow paths of the air, the second adsorption heat exchanger (52) operates as a condenser, the moisture desorbed from adsorption

desorption unit (desorption unit) (82) is added to the second target air (OA), and humidified air (SA) is supplied into the room. The first adsorption heat exchanger (51) operates as an evaporator, and the adsorption desorption unit (adsorption unit) (81) adsorbs moisture in the first target air (RA) and the dehumidified air (EA) is exhausted out of the room.

5 [0091]

For details, as illustrated in FIG. 9, the switching mechanism (40) sets a flow path of the air to a first path in the first action of the humidifying operation. Specifically, the second indoor air damper (42), the first outdoor air damper (43), the first air supply-side damper (45), and the second exhaust-side damper (48) are open, and the first indoor air damper (41), the
10 second outdoor air damper (44), the second air supply-side damper (46), and the first exhaust-side damper (47) are closed. Moreover, in the first action, the four-way switching valve (54) is in the first state (the state illustrated in FIG. 5A). The refrigerant circuit (50) performs the refrigeration cycle, in which the first adsorption heat exchanger (51) functions as a condenser (a radiator), and the second adsorption heat exchanger (52) functions as an evaporator.

15 [0092]

The first target air (RA) flowing into the indoor air path (32) flows into the second heat exchanger compartment (38) through the second indoor air damper (42), and thereafter passes through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (52) (first heat source), i.e., the adsorption desorption unit (adsorption unit) (82), the moisture
20 in the first target air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The first target air dehumidified by the adsorption unit (82) flows into an exhaust path (33) through the second exhaust-side damper (48), and the first target air (EA) after passing through the exhaust fan compartment (35) is exhausted to the outdoor space (201) via the exhaust port (21).

25 [0093]

On the other hand, the second target air (OA) flowing into the outdoor air path (34) flows into the first heat exchanger compartment (37) through the first outdoor air damper (43), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption heat exchanger (second heat source) (51), i.e., the adsorption desorption unit (desorption unit) (81), the moisture is desorbed from the adsorbent heated by the refrigerant, and the moisture thus desorbed is added to the second target air. The temperature of the second target air increases to some extent in the first adsorption heat exchanger (51). The second target air thus humidified by the desorption unit (81) flows into the air supply path (31) through the first air supply-side damper (45), and the second target air (SA) after passing through the air supply fan compartment (36) is supplied to the indoor space (200) through the air supply port (22).

[0094]

As illustrated in FIG. 10, the switching mechanism (40) sets the flow path of the air to a second path in a second action of the humidifying operation. Specifically, the first indoor air damper (41), the second outdoor air damper (44), the second air supply-side damper (46), and the first exhaust-side damper (47) are open, and the second indoor air damper (42), the first outdoor air damper (43), the first air supply-side damper (45), and the second exhaust-side damper (48) are closed. In the second action, the four-way switching valve (54) is in the second state (the state illustrated in FIG. 5B). The refrigerant circuit (50) performs the refrigeration cycle, in which the second adsorption heat exchanger (52) functions as a condenser (a radiator), and the first adsorption heat exchanger (51) functions as an evaporator.

[0095]

The first target air (RA) flowing into the indoor air path (32) flows into the first heat exchanger compartment (37) through the first indoor air damper (41), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption heat exchanger (first heat source) (51), i.e., the adsorption desorption unit (adsorption unit) (81), the moisture in the

first target air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The first target air dehumidified by the adsorption unit (81) flows into an exhaust path (33) via the first exhaust-side damper (47), and the first target air (EA) after passing through the exhaust fan compartment (35) is exhausted to the outdoor space (201) through the exhaust port (21).

[0096]

On the other hand, the second target air (OA) flowing into the outdoor air path (34) flows into the second heat exchanger compartment (38) through the second outdoor air damper (44), and thereafter passes through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (second heat source) (52), i.e., the adsorption desorption unit (desorption unit) (82), the moisture is desorbed from the adsorbent heated by the refrigerant, and the moisture thus desorbed is added to the second target air. The temperature of the second target air increases to some extent in the second adsorption heat exchanger (52). The second target air thus humidified by the desorption unit (82) flows into the air supply path (31) through the second air supply-side damper (46), and the second target air (SA) after passing through the air supply fan compartment (36) is supplied to the indoor space (200) through the air supply port (22).

[0097]

In the humidifying operation described above, based on temperature-humidity data (measured values by the sensors (91 to 94)) of the first target air exhausted out of the room from inside and the second target air supplied into the room from outside, the controller (95) may increase a temperature of the adsorption heat exchangers (51, 52) such that the relative humidity of the second target air reaching the desorption unit (81, 82) has a value in the vicinity of the first relative humidity value (RH1) in the desorption line, and lower a temperature of the adsorption heat exchangers (51, 52) such that the relative humidity of the first target air reaching

the adsorption unit (81, 82) has a value in the vicinity of the second relative humidity value (RH2) in the adsorption line. This allows, while improving energy efficiency, the second target air (OA) to be supplied into the room as humidified air (SA) and the first target air (RA) to be made into low-humidity air (EA) to be exhausted out of the room.

5 [0098]

[Ventilating Operation]

Under the ventilating operation, the humidity-controlling device (10) sucks, as first target air, the outdoor air through the outdoor air inlet (24) into the casing (11), and sucks, as second target air, the indoor air through the indoor air inlet (23) into the casing (11). In the
10 refrigerant circuit (50), the operation of the compressor (53), i.e., the refrigeration cycle stops. Under the ventilating operation, the humidity-controlling device (10) repeats the first and second actions to be described later each for, e.g., 3 min, alternatively. In other words, the ventilating operation is such that a first predetermined period, which is a time period for which the first or second action is continued, is 3 min.

15 [0099]

In the first action of the ventilating operation shown in FIG. 11, the first target air (OA) sucked into the outdoor air path (34) through the outdoor air inlet (24) flows into the air supply fan compartment (36) through the ventilation path (85), and the first target air (SA) after passing through the air supply fan compartment (36) is supplied to the indoor space (200) through the
20 air supply port (22). On the other hand, the second target air (RA) sucked into the indoor air path (32) through the indoor air inlet (23) flows into the first heat exchanger compartment (37) through the first indoor air damper (41), then flows into the exhaust path (33) through the first exhaust-side damper (47), and the second target air (EA) after passing through the exhaust fan compartment (35) is exhausted into the outdoor space (201) through the exhaust port (21). In
25 other words, in the first action of the ventilating operation, the first indoor air damper (41), the

first exhaust-side damper (47), the first ventilation damper (86), and the second ventilation damper (87) are open, and the second indoor air damper (42), the first outdoor air damper (43), the second outdoor air damper (44), the first air supply-side damper (45), the second air supply-side damper (46), and the second exhaust-side damper (48) are closed.

5 [0100]

In the second action of the ventilating operation shown in FIG. 12, the first target air (OA) sucked into the outdoor air path (34) through the outdoor air inlet (24) flows into the air supply fan compartment (36) through the ventilation path (85), and the first target air (SA) after passing through the air supply fan compartment (36) is supplied to the indoor space (200) through the air supply port (22). On the other hand, the second target air (RA) sucked into the indoor air path (32) through the indoor air inlet (23) flows into the second heat exchanger compartment (38) through the second indoor air damper (42), then flows into the exhaust path (33) through the second exhaust-side damper (48), and the second target air (EA) after passing through the exhaust fan compartment (35) is exhausted to the outdoor space (201) through the exhaust port (21). That is, in the second action of the ventilating operation, the second indoor air damper (42), the second exhaust-side damper (48), the first ventilation damper (86), and the second ventilation damper (87) are open, and the first indoor air damper (41), the first outdoor air damper (43), the second outdoor air damper (44), the first air supply-side damper (45), the second air supply-side damper (46), and the first exhaust-side damper (47) are closed.

20 [0101]

<Humidity Control>

The following describes a flowchart of humidity control by the controller (95) of the humidity-controlling device (10) according to this embodiment, with reference to FIG. 13.

[0102]

25 First, in Step S101, when the humidity-controlling device (10) is activated, the

controller (95) actuates the fans (25) and (26) and the dampers (41) to (48), (86), and (87).

[0103]

Next, in Step S102, the controller (95) acquires temperatures and relative humidities (temperature-humidity data measured by the sensors (91 to 94)) of the air (OA, RA: hereinafter, may also be collectively referred to as inlet air) sucked through the outdoor air inlet (24) and the indoor air inlet (23).

[0104]

Next, in Step S103, the controller (95) determines the selected operating mode, and controls the dampers (41) to (48), (86), and (87) and the four-way switching valves (54) in accordance with the operating mode.

[0105]

Specifically, when the “dehumidifying operation” is selected, in Step S104, the controller (95) operates the dampers (41) to (48) and the four-way switching valve (54) such that air (OA) sucked through the outdoor air inlet (24) passes through the adsorption heat exchanger (51, 52) which serves as an evaporator, and air (RA) sucked through the indoor air inlet (23) passes through the adsorption heat exchanger (51, 52) which serves as a condenser, to perform batch switching control of the first action and the second action.

[0106]

When the “humidifying operation” is selected, in Step S105, the controller (95) operates the dampers (41) to (48) and the four-way switching valve (54) such that air (OA) sucked through the outdoor air inlet (24) passes through the adsorption heat exchanger (51, 52) which serves as a condenser, and air (RA) sucked through the indoor air inlet (23) passes through the adsorption heat exchanger (51, 52) which serves as an evaporator, to perform batch switching control of the first action and the second action.

[0107]

Next, when the operating mode is the “dehumidifying operation” or the “humidifying operation,” in Step S106 subsequent to Step S104 or S105, based on the temperature-humidity data of the inlet air acquired in Step S102 and the adsorption property (the adsorption isotherm (the adsorption line and the desorption line), the first relative humidity value (RH1), and the second relative humidity value (RH2)) of the adsorbent, stored in advance, the controller (95) calculates a target temperature T_c of the adsorption heat exchanger (51, 52) which serves as a condenser and a target temperature T_e of the adsorption heat exchanger (51, 52) which serves as an evaporator. The target temperature T_c is set such that the moisture is desorbed from the desorption unit (81, 82) in the vicinity of the first relative humidity value (RH1) in the desorption line. The target temperature T_e is set such that the adsorption unit (81, 82) adsorbs moisture in the vicinity of the second relative humidity value (RH2) in the adsorption line.

[0108]

In the case where the adsorption property of the adsorbent has temperature dependency, the controller (95) may be configured such that the adsorption isotherm (the adsorption line and the desorption line) used in calculation of the target temperatures T_c and T_e is updated by a calculation formula, a table, or the like when the temperature of the adsorbent changes by control of the adsorption heat exchanger (heat source) (51, 52).

[0109]

Next, when the operating mode is the “dehumidifying operation” or the “humidifying operation,” in Step S107 subsequent to Step S106, based on the target temperatures T_c and T_e calculated in Step S106, the controller (95) starts heat pump (HP) operation control on the first adsorption heat exchanger (51) and the second adsorption heat exchanger (52).

[0110]

If it is determined that the “ventilating operation” is selected in Step S103, in Step S108, the controller (95) controls the dampers (86) and (87) such that the air (OA) sucked

through the outdoor air inlet (24) passes through the ventilation path (85).

[0111]

If the operating mode is the “ventilating operation,” calculation of the target temperatures T_c and T_e in Step S106 and the heat pump operation control in Step S107 are not performed.

[0112]

Next, in Step S109 subsequent to Step S107 or S108, the controller (95) determines whether or not there is a change in temperature and humidity of the inlet air, or whether or not there is a command to change the operating mode or to stop the operation of the device.

10 [0113]

If it is determined in Step S109 that the temperature and humidity of the inlet air have changed, and the operating mode is the “dehumidifying operation” or the “humidifying operation,” the process returns to Step S106, and the controller (95) recalculates the target temperatures T_c and T_e .

15 [0114]

If it is determined in Step S109 that the temperature and humidity of the inlet air have not changed, and the operating mode is the “dehumidifying operation” or the “humidifying operation,” the controller (95) maintains the heat pump operation based on the target temperatures T_c and T_e in Step S107.

20 [0115]

It is desirable that the target temperatures T_c and T_e of the condenser and the evaporator are achieved in a balanced manner in Step S107. However, the temperature of the adsorption heat exchanger (51, 52) which serves as a condenser or an evaporator may deviate from the target temperatures T_c and T_e and become temperature without artificial control. In such a case, the controller (95) may perform temperature control of the first adsorption heat exchanger (51)

and the second adsorption heat exchanger (52) so as to reduce waste of power consumption.

[0116]

If it is determined in Step S109 that a command to change the operating mode has been given, the process returns to Step S103, and the controller (95) performs control in accordance
5 with the operating mode after the change.

[0117]

If it is determined in Step S109 that a command to stop operation of the device has been given, in Step S110, the controller (95) stops the operation of the fans (25), (26) and the dampers (41) to (48), (86), and (87), stops the heat pump (HP) operation, and stops operation
10 of the humidity-controlling device (10).

[0118]

〈Features of First Embodiment〉

The humidity-controlling device (10) according to this embodiment performs dehumidification or humidification of a target space by using an adsorbent which adsorbs
15 moisture in the air. The humidity-controlling device (10) includes a controller (95) configured to control a temperature of the adsorbent or a relative humidity of air supplied to the adsorbent. In an adsorption isotherm of the adsorbent used in the humidity-controlling device (10), when a range less than a first relative humidity value (RH1) is a first range (I), a range equal to or higher than the first relative humidity value (RH1) and equal to or lower than a second relative
20 humidity value (RH2) ($RH2 > RH1$) is a second range (II), and a range exceeding the second relative humidity value (RH2) is a third range (III), a change in moisture content of the adsorbent to a change in relative humidity in the second range (II) is larger than a change in moisture content of the adsorbent to a change in relative humidity in the first range (I) and the third range (III). The controller (95) causes the adsorbent to desorb moisture in the vicinity of
25 the first relative humidity value (RH1), for example, in the range of ($RH1 - 10\%$) to (RH1),

preferably in the range of (RH1 – 5%) to (RH1), more preferably in the range of (RH1 – 3%) to (RH1). The controller (95) causes the adsorbent to adsorb moisture in the vicinity of the second relative humidity value (RH2), for example, in the range of (RH2) to (RH2 + 10%), preferably in the range of (RH2) to (RH2 + 5%), more preferably in the range of (RH2) to (RH2) + 3%).

[0119]

According to the humidity-controlling device (10) according to this embodiment, the controller (95) controls a temperature of the adsorbent or a relative humidity of the air supplied to the adsorbent, considering the adsorption property of the adsorbent. This makes it possible to reduce a temperature variation width of the heat source (the adsorption heat exchanger (51, 52)) for realizing the relative humidity range in which a required adsorption amount is obtained in the adsorbent, thereby improving energy efficiency.

[0120]

In the humidity-controlling device (10) according to this embodiment, an adsorbent having a so-called S-shaped adsorption property is used. This makes it possible to further reduce a temperature variation width of the heat source (the adsorption heat exchanger (51, 52)) for realizing the relative humidity range in which a required adsorption amount is obtained in the adsorbent, thereby further improving energy efficiency.

[0121]

The humidity-controlling device (10) according to this embodiment allows for a small temperature variation width when the adsorption heat exchanger (51, 52) carrying the adsorbent, i.e., the adsorption desorption unit (81, 82) is heated or cooled. This allows for reduction in stress variation of the adsorption desorption unit (81, 82) and the like due to a temperature change, or expansion and contraction of the adsorbent, thereby reducing deterioration of the adsorption desorption unit (81, 82) and extending the life of the adsorption desorption unit (81,

82).

[0122]

The humidity-controlling device (10) according to this embodiment allows for reduction in temperature difference between the condenser temperature (target T_c) and the evaporator temperature (target T_e) required for the dehumidifying operation and the humidifying operation in accordance with the adsorption property of the adsorbent. Therefore, the number of revolutions of the compressor (53) can be reduced as compared with the prior art, thereby improving the energy conservation of the humidity-controlling device (10).

[0123]

In the adsorbent used in the humidity-controlling device (10) according to this embodiment, the slope of the adsorption isotherm in the second range (II) may be five times or more the slope of the adsorption isotherm in each of the first range (I) and the third range (III). This allows for further improvement in energy efficiency.

[0124]

In the adsorbent used in the humidity-controlling device (10) according to this embodiment, a variation ΔW in the moisture content in the second range (II) may be 50% or more of the maximum moisture content of the adsorbent. This allows for further improvement in energy efficiency.

[0125]

In the adsorbent used in the humidity-controlling device (10) according to this embodiment, the difference between the second relative humidity value (RH2) and the first relative humidity value (RH1) may be 40% or less. This allows for further improvement in energy efficiency.

[0126]

The adsorbent used in the humidity-controlling device (10) according to this

embodiment may be a metal organic framework (MOF). This allows an adsorbent having a desired adsorption property to be obtained.

[0127]

The humidity-controlling device (10) according to this embodiment includes: an
5 adsorption desorption unit (81, 82) which carries an adsorbent and is configured to adsorb moisture in target air and desorb adsorbed moisture; a heat source (adsorption heat exchanger (51, 52)) configured to control a relative humidity at which the adsorption desorption unit (81, 82) adsorbs and desorbs moisture; a fan (25, 26) configured to control airflow of the target air; and an acquisition unit (sensor (91) to (94)) configured to acquire temperature-humidity data
10 of the target air. The controller (95) may control the temperature of the adsorption heat exchanger (51, 52) based on the temperature-humidity data acquired by the sensor (91) to (94). This allows for temperature control of the adsorption heat exchanger (51, 52) to achieve a relative humidity range in which a required adsorption amount is obtained in the adsorbent.

[0128]

15 In the adsorbent used in the humidity-controlling device (10) according to this embodiment, the adsorption isotherm may include an adsorption line when moisture is adsorbed, and a desorption line when adsorbed moisture is desorbed. In such a case, one of the adsorption desorption units (81, 82) may be an adsorption unit (81, 82) configured to adsorb moisture in target air, the other may be a desorption unit (81, 82) configured to desorb adsorbed moisture,
20 one of the adsorption heat exchangers (51, 52) may be a first heat source configured to control a relative humidity at which the adsorption unit (81, 82) adsorbs moisture, and the other may be a second heat source configured to control a relative humidity at which the desorption unit (81, 82) desorbs moisture. The controller (95) may control a temperature of one of the adsorption heat exchangers (51, 52) such that moisture is desorbed from the desorption unit (81,
25 82) in the vicinity of the first relative humidity value (RH1) in the desorption line, and control

a temperature of the other adsorption heat exchanger (51, 52) such that the adsorption unit (81, 82) adsorbs moisture in the vicinity of the second relative humidity value (RH2) in the adsorption line. This allows for desorption of moisture from the adsorbent of the desorption unit (81, 82) in the vicinity of the first relative humidity value (RH1) and allows the adsorbent
5 of the adsorption unit (81, 82) to adsorb moisture in the vicinity of the second relative humidity value (RH2).

[0129]

When the humidity-controlling device (10) according to this embodiment performs dehumidifying operation, based on temperature-humidity data (measured values by the sensors
10 (91 to 94)) of the first target air supplied into the room from outside and the second target air exhausted out of the room from inside, the controller (95) may lower a temperature of the adsorption heat exchanger (51, 52) which serves as a first heat source such that a relative humidity of the first target air reaching the adsorption unit (81, 82) has a value in the vicinity
15 of the second relative humidity value (RH2) in the adsorption line, and increase a temperature of the adsorption heat exchangers (51, 52) which serves as a second heat source such that the relative humidity of the second target air reaching the desorption unit (81, 82) has a value in the vicinity of the first relative humidity value (RH1) in the desorption line. This allows, while improving energy efficiency, the first target air to be supplied into the room as dehumidified air and the second target air to be made into high-humidity air to be exhausted out of the room.

[0130]

When the humidity-controlling device (10) according to this embodiment performs humidifying operation, based on temperature-humidity data (measured values by the sensors
(91 to 94)) of the first target air exhausted out of the room from inside and the second target air supplied into the room from outside, the controller (95) may increase a temperature of the
25 adsorption heat exchangers (51, 52) which serves as a second heat source such that a relative

humidity of the second target air reaching the desorption unit (81, 82) has a value in the vicinity of the first relative humidity value (RH1) in the desorption line, and lower a temperature of the adsorption heat exchanger (51, 52) which serves as a first heat source such that a relative humidity of the first target air reaching the adsorption unit (81, 82) has a value in the vicinity of the second relative humidity value (RH2) in the adsorption line. This allows, while improving energy efficiency, the second target air to be supplied into the room as humidified air and the first target air to be made into low-humidity air to be exhausted out of the room.

[0131]

In the humidity-controlling device (10) according to this embodiment, the first adsorption heat exchanger (51) and the second adsorption heat exchanger (52) may constitute a heat pump, and the controller (95) may control the temperatures of the first adsorption heat exchanger (51) and the second adsorption heat exchanger (52) in a coordinated manner. This allows further improvement in energy efficiency of the humidity-controlling device (10).

[0132]

(Second Embodiment)

A humidity-controlling device (110) according to the second embodiment performs dehumidification or humidification in a target space by using an adsorbent which adsorbs moisture in the air. The humidity-controlling device (110) controls a temperature of the adsorbent or a relative humidity of the air supplied to the adsorbent, considering the adsorption property of the adsorbent.

[0133]

The adsorbent used in the humidity-controlling device (110) according to this embodiment has, as in the first embodiment, a so-called S-shaped adsorption property (adsorption isotherm) as shown in FIG. 1, for example.

[0134]

The humidity-controlling device (110) according to this embodiment causes the adsorbent to desorb moisture in the vicinity of the first relative humidity value (RH1), for example, in the range of (RH1 – 10%) to (RH1), preferably in the range of (RH1 – 5%) to (RH1), more preferably in the range of (RH1 – 3%) to (RH1).

5 [0135]

The humidity-controlling device (110) according to this embodiment causes the adsorbent to adsorb moisture in the vicinity of the second relative humidity value (RH2), for example, in the range of (RH2) to (RH2 + 10%), preferably in the range of (RH2) to (RH2 + 5%), more preferably in the range of (RH2) to (RH2 + 3%).

10 [0136]

<Configuration of Humidity-Controlling Device>

The humidity-controlling device (110) according to this embodiment controls the humidity of the indoor space and ventilates the indoor space. The humidity-controlling device (110) controls the humidity of sucked outdoor air (OA) and supplies the air into the indoor
15 space as SA, while discharging sucked room air to an outdoor space as RA. The humidity-controlling device (110) may be installed together with an air conditioner. The humidity-controlling device (110) may be integral with an air conditioner, specifically an outdoor unit, for example.

[0137]

20 The humidity-controlling device (110) will be described in detail below with reference to FIG. 14.

[0138]

The humidity-controlling device (110) includes a casing (111). The casing (111) has a rectangular parallelepiped and slightly flattened shape with a relatively short height. The
25 internal space of the casing (111) is partitioned into a first air passage (113) and a second air

passage (114) by a partition (112). The first air passage (113) and the second air passage (114) are opposed to each other across the partition (112). An outdoor air inlet (111a) is formed at an outdoor-side end of the first air passage (113), and an air supply port (111b) is formed at an indoor-side end of the first air passage (113). An indoor air inlet (111c) is formed at an indoor-side end of the second air passage (114), and an exhaust port (111d) is formed at an outdoor-side end of the second air passage (114). Although not shown, an outdoor air suction duct may be connected to the outdoor air inlet (111a), an air supply duct may be connected to the air supply port (111b), an indoor air suction duct may be connected to the indoor air inlet (111c), and an exhaust duct may be connected to the exhaust port (111d).

10 [0139]

The humidity-controlling device (110) includes a humidity-controlling rotor (115) in such a posture that the humidity-controlling rotor (115) is positioned across both the first air passage (113) and the second air passage (114). The humidity-controlling rotor (115) is in a disc shape, for example. The humidity-controlling rotor (115) includes a substrate with a honeycomb structure and an adsorbent carried on the surface of the substrate, for example. The humidity-controlling rotor (115) is configured to allow the air to be passed in the thickness direction thereof, so that the air passing through the humidity-controlling rotor (115) comes into contact with the adsorbent. The substrate of the humidity-controlling rotor (115) may be made of a material such as ceramic paper, glass fibers, organic compounds whose main component is cellulose (for example, paper), metals, and resins. Instead of the humidity-controlling rotor (115) made in a disc shape, the humidity-controlling rotor (115) may be in a polygonal plate shape. Instead of being made in a honeycomb shape, the substrate of the humidity-controlling rotor (115) may be in a mesh-like shape or a filter-like shape.

[0140]

25 The humidity-controlling rotor (115) is configured to be driven by a motor (not

illustrated) to rotate on the center axis at a predetermined rate and move between the first air passage (113) and the second air passage (114). That is, a portion of the humidity-controlling rotor (115) in contact with air flowing through the first air passage (113) moves to the second air passage (114) with the rotation, and a portion of the humidity-controlling rotor (115) in contact with air flowing through the second air passage (114) again moves to the first air passage (113) with the rotation. Portions of the humidity-controlling rotor (115) positioned in the first air passage (113) and the second air passage (114) each function as an adsorption desorption unit (an adsorption unit or a desorption unit) (115A, 115B).

[0141]

An outdoor air temperature-humidity sensor (121) and an outdoor air filter (122) are installed in the vicinity of the outdoor air inlet (111a) in the first air passage (113). The outdoor air temperature-humidity sensor (121) measures a temperature and a relative humidity of the outdoor air (OA) flowing through the first air passage (113). The outdoor air filter (122) is for removing dust particles and the like from the air passing therethrough. An outdoor air heat source (the first heat source or the second heat source) (123) configured to control a relative humidity of air supplied to the humidity-controlling rotor (115) (the adsorption desorption unit (115A)) is installed upstream of the humidity-controlling rotor (115) in the first air passage (113). The outdoor air heat source (123) may be a heater and/or a cooler. An air supply fan (124) is installed downstream of the humidity-controlling rotor (115) in the first air passage (113). Upon operation of the air supply fan (124), the outdoor air is taken into the first air passage (113), and the taken outdoor air is, after passing through the humidity-controlling rotor (115), supplied into the room as SA.

[0142]

An indoor air temperature-humidity sensor (131) and an indoor air filter (132) are installed in the vicinity of the indoor air inlet (111c) in the second air passage (114). The indoor

air temperature-humidity sensor (131) measures a temperature and a relative humidity of the room air (RA) flowing through the second air passage (114). The indoor air filter (132) is for removing dust particles and the like from the air passing therethrough. An indoor air heat source (the first heat source or the second heat source) (133) configured to control a relative humidity of air supplied to the humidity-controlling rotor (115) (the adsorption desorption unit (115B)) is installed upstream of the humidity-controlling rotor (115) in the second air passage (114). The indoor air heat source (133) may be a heater and/or a cooler. An exhaust fan (134) is installed downstream of the humidity-controlling rotor (115) in the second air passage (114). Upon operation of the exhaust fan (134), the room air is taken into the second air passage (114), and the taken room air is, after passing through the humidity-controlling rotor (115), exhausted out of the room as EA.

[0143]

Although not shown in the figure, the humidity-controlling device (110) includes an electric component box including a control board on which the control unit (140) to be described later is mounted, a power supply board, and other components.

[0144]

<Control Unit>

The control unit (140) may include, e.g., a microcomputer and a memory device that stores software for operating the microcomputer. Measured values by the outdoor air temperature-humidity sensor (121) and the indoor air temperature-humidity sensor (131) are input to the control unit (140). The control unit (140) performs operation of the humidity-controlling device (110) based on these measured values input. In other words, the control unit (140) controls operations of the humidity-controlling rotor (115), the heat sources (123) and (133), and the fans (124) and (134).

[0145]

The control unit (140) controls a temperature of the adsorbent carried on each adsorption desorption unit (115A, 115B) or a relative humidity of the air supplied to the adsorbent. Specifically, based on the temperature-humidity data acquired by the outdoor air temperature-humidity sensor (121) and the indoor air temperature-humidity sensor (131), the control unit (140) controls the temperature of each of the heat sources (123) and (133) to cause the adsorbent (the desorption unit (115A, 115B) to desorb moisture in the vicinity of the first relative humidity value (RH1) and causes the adsorbent (the adsorption unit (115A, 115B)) to adsorb moisture in the vicinity of the second relative humidity value (RH2).

[0146]

The control unit (140) may independently control a temperature of the outdoor air heat source (123) and a temperature of the indoor air heat source (133).

[0147]

<Operation>

The humidity-controlling device (110) according to this embodiment selectively performs the dehumidifying operation, the humidifying operation, and the ventilating operation. The dehumidifying operation and the humidifying operation are humidity controlling operations for controlling the absolute humidity of the outdoor air to be supplied into the room. The ventilating operation is an operation simply for ventilating the room.

[0148]

In the dehumidifying operation and the humidifying operation, the humidity-controlling rotor (115), the heat sources (123) and (133), and the fans (124) and (134) operate. In the ventilating operation, the humidity-controlling rotor (115) and the fans (124) and (134) only operate. The humidity-controlling device (110) supplies outdoor air (OA) sucked therein into the room as supply air (SA), and exhausts room air (RA) sucked therein out of the room as the exhaust air (EA).

[0149]

When the adsorption isotherm of the adsorbent used in the humidity-controlling device (110) includes an adsorption line when moisture is adsorbed, and a desorption line when adsorbed moisture is desorbed, as illustrated in FIG. 1, the control unit (140) may control a temperature of the heat source (123, 124) to cause the desorption unit (115A, 115B) to desorb moisture in the vicinity of the first relative humidity value (RH1) in the desorption line and control a temperature of the heat source (123, 124) to cause the adsorption unit (115A, 115B) to adsorb moisture in the vicinity of the second relative humidity value (RH2) in the adsorption line.

10 [0150]

Hereinafter, the dehumidifying operation, the humidifying operation, and the ventilating operation performed by the humidity-controlling device (110) will be described in detail.

[0151]

15 [Dehumidifying Operation]

In the humidity-controlling device (110), the air supply fan (124) and the exhaust fan (134) operate, and the outdoor air heat source (123) and the indoor air heat source (133) are energized. Meanwhile, the humidity-controlling rotor (115) is rotated and driven at the predetermined number of revolutions by a motor (not illustrated).

20 [0152]

Outdoor air (OA) is taken into the first air passage (113). The outdoor air taken into the first air passage (113) is cooled by the outdoor air heat source (the first heat source) (123) and then sent to the adsorption desorption unit (the adsorption unit) (115A) of the humidity-controlling rotor (115), thereby coming into contact with the adsorbent. As a result of the contact with the outdoor air thus cooled, the adsorbent of the adsorption unit (115A) is cooled, so that

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the moisture contained in the outdoor air is adsorbed in the adsorbent. Low-humidity air thus dehumidified through the adsorption unit (115A) is supplied into the room as SA.

[0153]

5 The humidity-controlling rotor (115) is rotated at the predetermined number of revolutions. Thus, the adsorbent that adsorbs therein the moisture from outdoor air in the first air passage (113), i.e., the adsorption unit (115A) is moved to the second air passage (114) by rotation of the humidity-controlling rotor (115).

[0154]

Room air (RA) is taken into the second air passage (114). The room air taken into the
10 second air passage (114) is heated by the indoor air heat source (the second heat source) (133). The room air thus heated is sent to the adsorption desorption unit (desorption unit) (115B) of the humidity-controlling rotor (115) and comes into contact with the adsorbent. As a result of the contact with the room air thus heated, the adsorbent of the desorption unit (115B) is heated, so that the moisture is desorbed from the adsorbent. The moisture thus desorbed from the
15 adsorbent is exhausted out of the room together with the indoor air (EA) which has passed through the humidity-controlling rotor (115).

[0155]

The adsorbent thus regenerated by moisture desorption in the desorption unit (115B) is again moved to the first air passage (113) by the rotation of the humidity-controlling rotor
20 (115). As described above, the adsorbent is moved by the rotation of the humidity-controlling rotor (115) so as to repeat the moisture adsorption in the adsorption unit (115A) and the moisture desorption in the desorption unit (115B) alternately.

[0156]

In the dehumidifying operation described above, based on the temperature-humidity
25 data (measured values by the sensors (121, 131)) of the first target air supplied into the room

from outside and the second target air exhausted out of the room from inside, the control unit (140) may lower a temperature of the outdoor air heat source (first heat source) (123) such that the relative humidity of the first target air reaching the adsorption unit (115A) has a value in the vicinity of the second relative humidity value (RH2) in the adsorption line, and increase a temperature of the indoor air heat source (second heat source) (133) such that the relative humidity of the second target air reaching the desorption unit (115B) has a value in the vicinity of the first relative humidity value (RH1) in the desorption line. This allows, while improving energy efficiency, the first target air (OA) to be supplied into the room as dehumidified air (SA), and the second target air (RA) to be made into high-humidity air (EA) to be exhausted out of the room.

[0157]

[Humidifying Operation]

In the humidity-controlling device (110), the air supply fan (124) and the exhaust fan (134) operate, and the outdoor air heat source (123) and the indoor air heat source (133) are energized. Meanwhile, the humidity-controlling rotor (115) is rotated and driven at the predetermined number of revolutions by a motor (not illustrated).

[0158]

Outdoor air (OA) is taken into the first air passage (113). The outdoor air taken into the first air passage (113) is heated by the outdoor air heat source (second heat source) (123). The outdoor air thus heated is sent to the adsorption desorption unit (desorption unit) (115A) of the humidity-controlling rotor (115) and comes into contact with the adsorbent. As a result of the contact with the room air thus heated, the adsorbent of the desorption unit (115A) is heated, so that the moisture is desorbed from the adsorbent. The moisture thus desorbed from the adsorbent is added to the outdoor air which has been passed through the humidity-controlling rotor (115) to generate humidified air, which is then supplied into the room as SA.

[0159]

The humidity-controlling rotor (115) is rotated at the predetermined number of revolutions. Thus, the adsorbent from which moisture has been desorbed to humidify the outdoor air in the desorption unit (115A), i.e., the first air passage (113) is moved to the second
5 air passage (114) by rotation of the humidity-controlling rotor (115).

[0160]

Room air (RA) is taken into the second air passage (114). The room air taken into the second air passage (114) is cooled by the indoor air heat source (first heat source) (133) and then sent to the adsorption desorption unit (adsorption unit) (115B) of the humidity-controlling
10 rotor (115), thereby coming into contact with the adsorbent. As a result of the contact with the room air thus cooled, the adsorbent of the adsorption unit (115B) is cooled, so that the moisture contained in the room air is adsorbed in the adsorbent. Room air dehumidified through the adsorption unit (115B) is exhausted out of the room as EA.

[0161]

15 The adsorbent which has adsorbed moisture in the adsorption unit (115B) is again moved to the first air passage (113) by rotation of the humidity-controlling rotor (115). As described above, the adsorbent is moved by the rotation of the humidity-controlling rotor (115) so as to repeat the moisture adsorption in the adsorption unit (115B) and the moisture desorption in the desorption unit (115A) alternately.

20 [0162]

In the humidifying operation described above, based on temperature-humidity data (measured values by the sensors (121, 131)) of the first target air exhausted out of the room from inside and the second target air supplied into the room from outside, the control unit (140) may increase a temperature of the outdoor air heat source (second heat source) (123) such that
25 the relative humidity of the second target air reaching the desorption unit (115A) has a value in

the vicinity of the first relative humidity value (RH1) in the desorption line, and lower a temperature of the indoor air heat source (first heat source) (133) such that the relative humidity of the first target air reaching the adsorption unit (115B) has a value in the vicinity of the second relative humidity value (RH2) in the adsorption line. This allows, while improving energy efficiency, the second target air (OA) to be supplied into the room as humidified air (SA) and the first target air (RA) to be made into low-humidity air (EA) to be exhausted out of the room.

[0163]

[Ventilating Operation]

In the humidity-controlling device (110) under the ventilating operation, the air supply fan (124), the exhaust fan (134), and the humidity-controlling rotor (115) operate, the outdoor air (OA) is sucked into the first air passage (113) through the outdoor air inlet (111a), and the room air (RA) is sucked into the second air passage (114) through the indoor air inlet (111c). The operations of the outdoor air heat source (123) and the indoor air heat source (133) stop.

[0164]

The outdoor air sucked into the first air passage (113) through the outdoor air inlet (111a) passes through the humidity-controlling rotor (115) and is supplied into the room through the air supply port (111b) as SA. On the other hand, the room air (RA) sucked into the second air passage (114) through the indoor air inlet (111c) passes through the humidity-controlling rotor (115) and is exhausted out of the room through the exhaust port (111d) as EA.

[0165]

<Humidity Control>

The following describes a flowchart of humidity control by the control unit (140) of the humidity-controlling device (110) according to this embodiment with reference to FIG. 15.

[0166]

First, in Step S201, when the humidity-controlling device (110) is activated, the control

unit (140) actuates the air supply fan (124), the exhaust fan (134), and the humidity-controlling rotor (115).

[0167]

Next, in Step S202, the control unit (140) acquires temperatures and relative humidities (temperature-humidity data acquired by the sensor (121, 131)) of the air (OA, RA, hereinafter, may also be collectively referred to as inlet air) sucked through the outdoor air inlet (111a) and the indoor air inlet (111c).

[0168]

Next, in Step S203, the control unit (140) determines the operating mode selected and controls the heat sources (123) and (133) in accordance with the operating mode.

[0169]

Specifically, when the “dehumidifying operation” or the “humidifying operation” is selected, in Step S204, based on the temperature-humidity data of the inlet air acquired in Step S202 and the adsorption property (the adsorption isotherm (the adsorption line and the desorption line), the first relative humidity value (RH1), and the second relative humidity value (RH2)) stored in advance of the adsorbent, the control unit (140) calculates target temperatures of the heat sources (123) and (133). The target temperatures of the heat sources (123) and (133) are set such that the moisture is desorbed from the desorption unit (115A, 115B) in the vicinity of the first relative humidity value (RH1) in the desorption line, and the adsorption unit (115A, 115B) adsorbs moisture in the vicinity of the second relative humidity value (RH2) in the adsorption line.

[0170]

In the case where the adsorption property of the adsorbent has temperature dependency, the control unit (140) may be configured such that the adsorption isotherm (the adsorption line and the desorption line) used in calculation of the target temperatures is updated by a calculation

formula, a table, or the like when the temperature of the adsorbent changes by control of the heat sources (123) and (133).

[0171]

Next, if the operating mode is the “dehumidifying operation” or the “humidifying operation,” in Step S205 subsequent to Step S204, the control unit (140) starts temperature control of the heat sources (123) and (133) based on the target temperatures calculated in Step S204.

[0172]

In Step 205, in consideration of the case where the relative humidity of the adsorption desorption unit (115A, 115B) deviates from the target value due to temperature drop caused by the distance from each of the heat sources (123) and (133) to the humidity-controlling rotor (115), the temperature drop may be corrected to perform temperature control of each of the heat sources (123) and (133).

[0173]

If the operating mode is the “ventilating operation,” the process proceeds to Step S206 without calculation of target temperature in Step S204 and heat source control in Step S205.

[0174]

Next, in Step S206, the control unit (140) determines whether or not there is a change in temperature and humidity of the inlet air, and whether or not there is a command to change the operating mode or to stop the operation of the device.

[0175]

If it is determined in Step S206 that the temperature and humidity of the inlet air have changed, and the operating mode is the “dehumidifying operation” or the “humidifying operation,” the process returns to Step S204, and the control unit (140) recalculates the target temperature of each of the heat sources (123) and (133).

[0176]

If it is determined in Step S206 that the temperature and humidity of the inlet air have not changed, and the operating mode is the “dehumidifying operation” or the “humidifying operation,” the control unit (140) maintains temperature control of each of the heat sources (123) and (133) in Step S205.

[0177]

If it is determined in Step S206 that the command to change the operating mode has been given, the process returns to Step S203, and the control unit (140) performs control in accordance with the operating mode after the change.

10 [0178]

If it is determined in Step S206 that a command to stop operation of the device has been given, in Step S207, the control unit (140) stops operations of the fans (124) and (134) and the humidity-controlling rotor (115), stops the operation of the heat sources (123) and (133), and stops the operation of the humidity-controlling device (110).

15 [0179]

<Features of Second Embodiment>

A humidity-controlling device (110) according to this embodiment performs dehumidification or humidification in a target space by using an adsorbent which adsorbs moisture in the air. The humidity-controlling device (110) includes a control unit (140) configured to control a temperature of the adsorbent or a relative humidity of air supplied to the adsorbent. In an adsorption isotherm of the adsorbent used in the humidity-controlling device (110), when a range less than a first relative humidity value (RH1) is a first range (I), a range equal to or higher than the first relative humidity value (RH1) and equal to or lower than a second relative humidity value (RH2) (RH2 > RH1) is a second range (II), and a range exceeding the second relative humidity value (RH2) is a third range (III), a change in moisture

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content of the adsorbent to a change in relative humidity in the second range (II) is larger than a change in moisture content of the adsorbent to a change in relative humidity in the first range (I) and the third range (III). The control unit (140) causes the adsorbent to desorb moisture in the vicinity of the first relative humidity value (RH1), for example, in the range of (RH1 – 10%) to (RH1), preferably in the range of (RH1 – 5%) to (RH1), more preferably in the range of (RH1 – 3%) to (RH1). The control unit (140) causes the adsorbent to adsorb moisture in the vicinity of the second relative humidity value (RH2), for example, in the range of (RH2) to (RH2 + 10%), preferably in the range of (RH2) to (RH2 + 5%), more preferably in the range of (RH2) to (RH2 + 3%).

10 [0180]

According to the humidity-controlling device (110) according to this embodiment, the control unit (140) controls a temperature of the adsorbent or a relative humidity of the air supplied to the adsorbent, considering the adsorption property of the adsorbent. This makes it possible to reduce a temperature variation width of the heat source (123,133) for realizing the relative humidity range in which a required adsorption amount is obtained in the adsorbent, thereby improving energy efficiency.

[0181]

In the humidity-controlling device (110) according to this embodiment, an adsorbent having a so-called S-shaped adsorption property is used. This makes it possible to further reduce a temperature variation width of the heat source (123,133) for realizing the relative humidity range in which a required adsorption amount is obtained in the adsorbent, thereby further improving energy efficiency.

[0182]

The humidity-controlling device (110) according to this embodiment allows for a small temperature variation width when the humidity-controlling rotor (115) carrying the adsorbent,

i.e., the adsorption desorption unit (115A, 115B) is heated or cooled. This allows for reduction in stress variation of the adsorption desorption unit (115A, 115B) and the like due to a temperature change, or expansion and contraction of the adsorbent, thereby reducing deterioration of the adsorption desorption unit (115A, 115B) and extending the life of the
5 adsorption desorption unit (115A, 115B).

[0183]

In the adsorbent used in the humidity-controlling device (110) according to this embodiment, the slope of the adsorption isotherm in the second range (II) may be five times or more the slope of the adsorption isotherm in each of the first range (I) and the third range (III).

10 This can further improve energy efficiency.

[0184]

In the adsorbent used in the humidity-controlling device (110) according to this embodiment, a variation ΔW in the moisture content in the second range (II) may be 50% or more of the maximum moisture content of the adsorbent. This allows for further improvement
15 in energy efficiency.

[0185]

In the adsorbent used in the humidity-controlling device (110) according to this embodiment, the difference between the second relative humidity value (RH2) and the first relative humidity value (RH1) may be 40% or less. This allows for further improvement in
20 energy efficiency.

[0186]

The adsorbent used in the humidity-controlling device (110) according to this embodiment may be a metal organic framework (MOF). This allows an adsorbent having a desired adsorption property to be obtained.

25 [0187]

The humidity-controlling device (110) according to this embodiment includes: an adsorption desorption unit (115A, 115B) which carries an adsorbent and is configured to adsorb moisture in target air and desorb adsorbed moisture; a heat source (123, 133) configured to control a relative humidity at which the adsorption desorption unit (115A, 115B) adsorbs and desorbs moisture; a fan (124,134) configured to control airflow of the target air; and an acquisition unit (sensor (121, 131)) configured to acquire temperature-humidity data of the target air. The control unit (140) may control the temperature of the heat source (123, 133) based on the temperature-humidity data acquired by the sensor (121, 131). This allows temperature control of the heat source (123, 133) to achieve a relative humidity range in which a required adsorption amount is obtained in the adsorbent.

[0188]

In the adsorbent used in the humidity-controlling device (110) according to this embodiment, the adsorption isotherm may include an adsorption line when moisture is adsorbed, and a desorption line when adsorbed moisture is desorbed. In such a case, one of the adsorption desorption units (115A, 115B) may be an adsorption unit (115A, 115B) configured to adsorb moisture in target air, the other may be a desorption unit (115A, 115B) configured to desorb adsorbed moisture, one of the heat sources (123, 133) may be a first heat source configured to control a relative humidity at which the adsorption unit (115A, 115B) adsorbs moisture, and the other may be a second heat source configured to control a relative humidity at which the desorption unit (115A, 115B) desorbs moisture. The control unit (140) may control a temperature of one of the heat sources (123, 133) to cause the desorption unit (115A, 115B) to desorb moisture in the vicinity of the first relative humidity value (RH1) in the desorption line and control a temperature of the other one of the heat sources (123, 133) to cause the adsorption unit (115A, 115B) to adsorb moisture in the vicinity of the second relative humidity value (RH2) in the adsorption line. This allows for desorption of moisture from the adsorbent of the

desorption unit (115A, 115B) in the vicinity of the first relative humidity value (RH1) and allows the adsorbent of the adsorption unit (115A, 115B) to adsorb moisture in the vicinity of the second relative humidity value (RH2).

[0189]

5 When the humidity-controlling device (110) according to this embodiment performs dehumidifying operation, based on the temperature-humidity data (measured values by the sensors (121, 131)) of the first target air supplied into the room from outside and the second target air exhausted out of the room from inside, the control unit (140) may lower a temperature of the outdoor air heat source (first heat source) (123) such that the relative humidity of the first
10 target air reaching the adsorption unit (115A) has a value in the vicinity of the second relative humidity value (RH2) in the adsorption line, and increase a temperature of the indoor air heat source (second heat source) (133) such that the relative humidity of the second target air reaching the desorption unit (115B) has a value in the vicinity of the first relative humidity value (RH1) in the desorption line. This allows, while improving energy efficiency, the first
15 target air to be supplied into the room as dehumidified air and the second target air to be made into high-humidity air to be exhausted out of the room.

[0190]

 When the humidity-controlling device (110) according to this embodiment performs humidifying operation, based on temperature-humidity data (measured values by the sensors
20 (121, 131)) of the first target air exhausted out of the room from inside and the second target air supplied into the room from outside, the control unit (140) may increase a temperature of the outdoor air heat source (second heat source) (123) such that the relative humidity of the second target air reaching the desorption unit (115A) has a value in the vicinity of the first relative humidity value (RH1) in the desorption line, and lower a temperature of the indoor air
25 heat source (first heat source) (133) such that the relative humidity of the first target air reaching

the adsorption unit (115B) has a value in the vicinity of the second relative humidity value (RH2) in the adsorption line. This allows, while improving energy efficiency, the second target air to be supplied into the room as humidified air and the first target air to be made into low-humidity air to be exhausted out of the room.

5 [0191]

In the humidity-controlling device (110) according to this embodiment, the outdoor air heat source (123) and the indoor air heat source (133) may not constitute a heat pump. The control unit (140) independently controls a temperature of the outdoor air heat source (123) and a temperature of the indoor air heat source (133). This allows simplification of the configuration
10 of the humidity-controlling device (110).

[0192]

(Other Embodiments)

In the embodiments described above, the humidity-controlling device (10, 110) is configured as a humidity-controlling ventilating unit capable of performing dehumidification,
15 humidification, and ventilation. However, the configuration, arrangement, and the like of the humidity-controlling device of the present disclosure are not particularly limited as long as the humidity-controlling device performs at least dehumidification or humidification. For example, the humidity-controlling device of the present disclosure may not have a ventilation function. The humidity-controlling device of the present disclosure may be integral with or separate from
20 the air conditioning indoor unit to be installed in the room, or may be integral with or separate from the air conditioning outdoor unit to be installed outside of the room.

[0193]

In the embodiments described above, a heat pump (heat exchanger) or a heater is used as a heat source (51, 52, 123, 133) used in the humidity-controlling device (10, 110). However,
25 the type of the heat source (51, 52, 123, 133) is not particularly limited, and for example, hot

and chilled water, waste water, or the like may be used as the heat source.

[0194]

While the embodiments have been described above, it will be understood that various changes in form and details can be made without departing from the spirit and scope of the claims. The foregoing embodiments may be appropriately combined or replaced. In addition, the expressions of “first,” “second,” . . . described above are used to distinguish the terms to which these expressions are given, and do not limit the number and order of the terms.

INDUSTRIAL APPLICABILITY

10 [0195]

As can be seen from the foregoing description, the present disclosure is useful for a humidity-controlling device.

DESCRIPTION OF REFERENCE CHARACTERS

15 [0196]

10 Humidity-Controlling Device

25 Exhaust Fan (Fan)

26 Air Supply Fan (Fan)

51 First Adsorption Heat Exchanger (Heat Source (First Heat Source or Second Heat
20 Source))

52 Second Adsorption Heat Exchanger (Heat Source (First Heat Source or Second Heat
Source))

81, 82 Adsorption Desorption Unit (Adsorption Unit or Desorption Unit)

91 Indoor Air Temperature Sensor (Acquisition Unit)

25 92 Indoor Air Humidity Sensor (Acquisition Unit)

	93	Outdoor Air Temperature Sensor (Acquisition Unit)
	94	Outdoor Air Humidity Sensor (Acquisition Unit)
	95	Controller (Control Unit)
	110	Humidity-Controlling Device
5	115	Humidity-Controlling Rotor
	115A, 115B	Adsorption Desorption Unit (Adsorption Unit or Desorption Unit)
	121	Outdoor Air Temperature-Humidity Sensor (Acquisition Unit)
	123	Outdoor Air Heat Source (First Heat Source or Second Heat Source)
	124	Air Supply Fan (Fan)
10	131	Indoor Air Temperature-Humidity Sensor (Acquisition Unit)
	133	Indoor Air Heat Source (First Heat Source or Second Heat Source)
	134	Exhaust Fan (Fan)
	140	Control Unit

CLAIMS

1. A humidity-controlling device (10, 110) using an adsorbent which adsorbs moisture in air, the humidity-controlling device (10, 110) comprising:

5 a control unit (95, 140) configured to control a temperature of the adsorbent or a relative humidity of air supplied to the adsorbent, wherein

when, in an adsorption isotherm of the adsorbent, a range less than a first relative humidity value is a first range, a range equal to or higher than the first relative humidity value and equal to or lower than a second relative humidity value (the second relative humidity value > the first relative humidity value) is a second range, and a range exceeding the second relative humidity value is a third range, a change in moisture content of the adsorbent to a change in relative humidity in the second range is larger than a change in moisture content of the adsorbent to a change in relative humidity in the first range and the third range, and

the control unit (95, 140) causes the adsorbent to desorb moisture in a vicinity of the first relative humidity value and causes the adsorbent to adsorb moisture in a vicinity of the second relative humidity value.

2. The humidity-controlling device of claim 1, wherein

a slope of the adsorption isotherm of the adsorbent in the second range is five times or more a slope of the adsorption isotherm of the adsorbent in the first range and the third range.

3. The humidity-controlling device of claim 1 or 2, wherein

a variation in moisture content of the adsorbent in the second range is 50% or more of a maximum moisture content of the adsorbent.

4. The humidity-controlling device of any one of claims 1 to 3, wherein
a difference between the second relative humidity value and the first relative humidity
value is 40% or less.

5 5. The humidity-controlling device of any one of claims 1 to 4, wherein
the vicinity of the first relative humidity value is a range from -10% of the first relative
humidity value to the first relative humidity value, and
the vicinity of the second relative humidity value is a range from the second relative
humidity value to +10% of the second relative humidity value.

10 6. The humidity-controlling device of any one of claims 1 to 5, wherein
the adsorbent has a metal organic framework.

7. The humidity-controlling device of any one of claims 1 to 6, further
15 comprising:

an adsorption desorption unit (81, 82, 115A, 115B) including the adsorbent and
configured to adsorb moisture in target air and desorb the moisture adsorbed;

a heat source (51, 52, 123, 133) configured to control a relative humidity at which the
adsorption desorption unit (81, 82, 115A, 115B) adsorbs and desorbs moisture;

20 a fan (25, 26, 124, 134) configured to control airflow of the target air; and

an acquisition unit (91, 92, 93, 94, 121, 131) configured to acquire temperature-
humidity data of the target air,

wherein

the control unit (95, 140) controls a temperature of the heat source (51, 52, 123, 133)
25 based on the temperature-humidity data acquired by the acquisition unit (91, 92, 93, 94, 121,

131).

8. The humidity-controlling device of claim 7, wherein

the adsorption isotherm of the adsorbent includes an adsorption line when moisture is
5 adsorbed, and a desorption line when adsorbed moisture is desorbed,

the adsorption desorption unit (81, 82, 115A, 115B) includes: an adsorption unit (81, 82, 115A, 115B) configured to adsorb moisture in the target air; and a desorption unit (81, 82, 115A, 115B) configured to desorb moisture adsorbed,

the heat source (51, 52, 123, 133) includes a first heat source (51, 52, 123, 133)
10 configured to control a relative humidity at which the adsorption unit (81, 82, 115A, 115B) adsorbs moisture; and a second heat source (51, 52, 123, 133) configured to control a relative humidity at which the desorption unit (81, 82, 115A, 115B) desorbs moisture,

the control unit (95, 140) controls a temperature of the second heat source (51, 52, 123, 133) such that moisture is desorbed from the desorption unit (81, 82, 115A, 115B) in the vicinity
15 of the first relative humidity value in the desorption line, and controls a temperature of the first heat source (51, 52, 123, 133) such that the adsorption unit (81, 82, 115A, 115B) adsorbs moisture in the vicinity of the second relative humidity value in the adsorption line.

9. The humidity-controlling device of claim 8, wherein

20 when a room is dehumidified, based on temperature-humidity data of first target air supplied into the room from outside and a second target air exhausted out of the room from inside, the control unit (95, 140) performs control to lower a temperature of the first heat source (51, 52, 123, 133) such that a relative humidity of the first target air reaching the adsorption unit (81, 82, 115A, 115B) has a value in the vicinity of the second relative humidity value in
25 the adsorption line, and to increase a temperature of the second heat source (51, 52, 123, 133)

such that a relative humidity of the second target air reaching the desorption unit (81, 82, 115A, 115B) has a value in the vicinity of the first relative humidity value in the desorption line, thereby supplying the first target air into the room as dehumidified air and making the second target air into high-humidity air to be exhausted out of the room.

5

10. The humidity-controlling device of claim 8 or 9, wherein

when a room is humidified, based on temperature-humidity data of the first target air exhausted out of the room from inside and the second target air supplied into the room from outside, the control unit (95, 140) increases a temperature of the second heat source (51, 52, 123, 133) such that a relative humidity of the second target air reaching the desorption unit (81, 82, 115A, 115B) has a value in the vicinity of the first relative humidity value in the desorption line, and lowers a temperature of the first heat source (51, 52, 123, 133) such that a relative humidity of the first target air reaching the adsorption unit (81, 82, 115A, 115B) has a value in the vicinity of the second relative humidity value in the adsorption line, thereby supplying the second target air into the room as humidified air and making the first target air into low-humidity air to be exhausted out of the room.

11. The humidity-controlling device of any one of claims 8 to 10, wherein the first heat source (51, 52) and the second heat source (51, 52) constitute a heat pump, and the control unit (95) controls a temperature of the first heat source (51, 52) and a temperature of the second heat source (51, 52) in a coordinated manner.

12. The humidity-controlling device of any one of claims 8 to 10, wherein the first heat source (123, 133) and the second heat source (123, 133) do not constitute

a heat pump, and

the control unit (140) independently controls a temperature of the first heat source (123, 133) and a temperature of the second heat source (123, 133).