

DESCRIPTION

TITLE: ADSORPTION SYSTEM

5 TECHNICAL FIELD

[0001]

The present disclosure relates to an adsorption system.

BACKGROUND ART

10 [0002]

An adsorption system including an adsorbent has been known.

[0003]

An adsorption system disclosed in Patent Document 1 is employed in a humidity control apparatus. The humidity control apparatus conducts a dehumidifying operation and a
15 humidifying operation. In the dehumidifying operation, moisture in the air is adsorbed by an adsorbent. The air from which the moisture has been removed is supplied to a target space. In the humidifying operation, the moisture desorbed from the adsorbent is released into the air. The humidified air is supplied to the target space.

20 CITATION LIST

PATENT DOCUMENT

[0004]

PATENT DOCUMENT 1: Japanese Unexamined Patent Publication No. 2001-096126

25 SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005]

Microorganisms, such as mold and fungi, multiply on the surface of the adsorbent. If microorganisms multiply, the microorganisms themselves, or malodors released from the microorganisms, are supplied to the target space. As a result, the comfort and hygienic conditions of the target space are impaired.

[0006]

It is an objective of the present disclosure to provide an adsorption system that can reduce the multiplication of fungi in an adsorbent.

10

SOLUTION TO THE PROBLEM

[0007]

A first aspect is directed to an adsorption system comprising: an adsorption section (51, 52) having an adsorbent (57) that adsorbs a target substance; and a generation section (56) configured to generate water on a surface of the adsorbent (57). The adsorbent (57) has the property of making the water on the surface acidic or alkaline.

[0008]

According to the first aspect, the water generated on the surface of the adsorbent (57) by the generation section (56) becomes acidic or alkaline. The acidic or alkaline water can reduce the multiplication of microorganisms on the surface of the adsorbent (57).

[0009]

A second aspect is the adsorption system of the first aspect, in which the generation section includes a cooling portion (56) configured to cool air so as to generate condensation water.

25 [0010]

According to the second aspect, condensation water is generated from air when the cooling portion (56) as the generation section cools the air. This water adheres to the surface of the adsorbent (57) and becomes acidic or alkaline.

[0011]

5 A third aspect is the adsorption system of the second aspect, in which the adsorption section includes a heat exchanger (56) **having the adsorbent (57)**, and the cooling portion is the heat exchanger (56) functioning as an evaporator.

[0012]

 According to the third aspect, when the heat exchanger (56) as the cooling portion
10 functions as an evaporator, condensation of the moisture in the air occurs, and the condensation water adheres to the surface of the adsorbent (57). This water becomes acidic or alkaline.

[0013]

 A fourth aspect is the adsorption system of the third aspect, including a control device (95) configured to cause a first action in which the heat exchanger (56) functions as an
15 evaporator and a second action in which the heat exchanger (56) functions as a radiator to occur alternately, wherein the heat exchanger (56) cools the air in the first action so as to generate the condensation water.

[0014]

 According to the fourth aspect, the control device (95) causes the first action and the
20 second action to occur alternately. In the first action, the control device (95) causes the heat exchanger (56) to function as an evaporator. Accordingly, moisture in the air can be adsorbed onto the adsorbent (57). In the second action, the control device (95) causes the heat exchanger (56) to function as a radiator. Accordingly, the moisture adsorbed by the adsorbent (57) can be desorbed into the air. Alternately performing the first action and the second action allows
25 alternate adsorption and desorption of the moisture to and from the adsorbent (57).

[0015]

Further, in the first action, air is cooled by the heat exchanger (56) functioning as an evaporator, thereby generating condensation water. It is possible to generate acidic or alkaline water on the surface of the adsorbent (57) when this condensation water adheres to the surface of the adsorbent (57). The multiplication of microorganisms can be reduced during alternate adsorption and desorption of the moisture.

[0016]

A fifth aspect is the adsorption system of any one of the first to fourth aspects, in which the adsorbent (57) has a property of making the water on the surface acidic with a Lewis acid.

10 [0017]

According to the fifth aspect, the water on the surface of the adsorbent (57) is made acidic or alkaline with a Lewis acid generated from the adsorbent (57).

[0018]

A sixth aspect is the adsorption system of any one of the first to fourth aspects, in which the adsorbent (57) includes a metal organic framework.

[0019]

According to the sixth aspect, the water on the surface of the adsorbent (57) is made acidic with a metal organic framework included in the adsorbent (57).

[0020]

20 A seventh aspect is the adsorption system of any one of the first to fourth aspects, in which the adsorbent (57) includes silica gel.

[0021]

According to the seventh aspect, the water on the surface of the adsorbent (57) is made acidic with silica gel included in the adsorbent (57).

25 [0022]

An eighth aspect is the adsorption system of any one of the first to fourth aspects, in which the adsorbent (57) includes sodium polyacrylate.

[0023]

According to the eighth aspect, the water on the surface of the adsorbent (57) is made
5 alkaline with sodium polyacrylate included in the adsorbent (57).

[0024]

A ninth aspect is the adsorption system of any one of the first to fourth aspects, in which the adsorbent (57) has a property of making the water on the surface have a pH of 5 or less or 9 or more.

10 [0025]

According to the ninth aspect, the pH of the water on the surface of the adsorbent (57) is suitable for further reducing the multiplication of microorganisms.

[0026]

A tenth aspect is the adsorption system of the ninth aspect, in which the adsorbent (57)
15 has a property of making the water on the surface have a pH of a range between 2 and 4.

[0027]

According to the tenth aspect, the pH of the water on the surface of the adsorbent (57) is suitable for further reducing the multiplication of microorganisms.

[0028]

20 An eleventh aspect is the adsorption system of the ninth aspect, in which the adsorbent (57) has a property of making the water on the surface have a pH of less than 2.

[0029]

According to the eleventh aspect, the pH of the water on the surface of the adsorbent (57) is suitable for further reducing the multiplication of microorganisms.

25

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a diagram illustrating a general configuration of a humidity control apparatus according to an embodiment.

5 FIGS. 2A and 2B are piping system diagrams of a refrigerant circuit of the humidity control apparatus according to the embodiment.

FIG. 3 is a block diagram illustrating a connection relationship of a controller according to the embodiment with other components.

FIG. 4 is a view corresponding to FIG. 1, illustrating the flow of air in a first
10 dehumidifying action.

FIG. 5 is a view corresponding to FIG. 1, illustrating the flow of air in a second dehumidifying action.

FIG. 6 is a view corresponding to FIG. 1, illustrating the flow of air in a first humidifying action.

15 FIG. 7 is a view corresponding to FIG. 1, illustrating the flow of air in a second humidifying action.

FIG. 8 is a timing chart of a dehumidifying operation.

FIG. 9 is a timing chart of a humidifying operation.

FIG. 10 is a table showing types of microorganisms and ranges of the pH for the growth
20 of the microorganisms.

DESCRIPTION OF EMBODIMENTS

[0031]

An embodiment of the present disclosure will be described below with reference to the
25 drawings. The following embodiment is merely an exemplary one in nature, and is not intended

to limit the scope, applications, or use of the present invention.

[0032]

<General Configuration of Adsorption System>

An adsorption system according to the present invention is employed in a humidity
5 control apparatus (10). The humidity control apparatus (10) adjusts the humidity of air in a
target space. The target space is an indoor space. The humidity control apparatus (10) switches
between a dehumidifying operation in which air is dehumidified and a humidifying operation
in which air is humidified. The target substance of the humidity control apparatus (10) is
moisture in the air. The humidity control apparatus (10) adjusts the humidity of the air in the
10 indoor space and ventilates the indoor space. The humidity control apparatus (10) includes a
humidity control unit (U), a refrigerant circuit (50), and a controller (100).

[0033]

<Humidity Control Unit>

The humidity control unit (U) will be described in detail below with reference to FIG.

15 1. 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 control unit (U) is viewed from the front.

[0034]

The humidity control unit (U) includes a casing (11). The casing (11) houses therein
20 the refrigerant circuit (50). 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 first refrigerant
circuit (50) will be described in detail later.

[0035]

25 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) communicates with the outdoor space via a first duct. The indoor air inlet (23) communicates with the indoor space via a second duct. The air supply port (22) communicates with the indoor space via a third duct. The exhaust port (21) communicates with the outdoor space via a fourth duct.

[0036]

The outdoor air inlet (24) and the indoor air inlet (23) are provided on a back panel 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 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).

[0037]

An upstream partition plate (71), a downstream partition plate (72), and a center partition plate (73) are provided in the internal space of the casing (11). All of 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).

[0038]

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.

[0039]

5 Inside the casing (11), a space between the upstream partition plate (71) and the back panel portion (13) is partitioned into upper and lower spaces: The upper space constitutes an indoor air path (32), and the lower space constitutes an outdoor air path (34). The indoor air path (32) communicates with the indoor air inlet (23), and the outdoor air path (34) communicates with the outdoor air inlet (24).

10 [0040]

 The indoor air path (32) is provided with an indoor air-side filter (27), an indoor air temperature sensor (91), and an indoor air humidity sensor (92). The indoor air temperature sensor (91) is configured to measure a temperature of the room air flowing through the indoor air path (32). The indoor air humidity sensor (92) is configured to measure a relative humidity
15 of the room air flowing through the indoor air path (32). The outdoor air path (34) is provided with an outdoor air-side filter (28), an outdoor air temperature sensor (93), and an outdoor air humidity sensor (94). The outdoor air temperature sensor (93) is configured to measure a temperature of the outdoor air flowing through the outdoor air path (34). The outdoor air humidity sensor (94) is configured to measure a relative humidity of the outdoor air flowing
20 through the outdoor air path (34). 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 omitted in FIGS. 4 to 7.

[0041]

 Inside the casing (11), a space between the upstream partition plate (71) and the
25 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). The first heat exchanger compartment (37) houses the first adsorption heat exchanger (51). The second heat exchanger compartment (38) houses the second adsorption heat exchanger (52). Further, although not illustrated, the first heat exchanger compartment (37) houses the electrically powered expansion valve (55) of the refrigerant circuit (50).

[0042]

Each of the adsorption heat exchangers (51, 52) is an adsorption section that adsorbs the target substance. As illustrated in FIGS. 2A and 2B, each of the adsorption heat exchangers (51, 52) has a heat exchanger (56) and an adsorbent (57) provided on the surface of the heat exchanger (56). The heat exchanger (56) is a so-called cross-fin-type fin-and-tube heat exchanger. The adsorbent (57) is supported on the surface of the heat exchanger (56). The adsorbent (57) will be described in detail later.

[0043]

Each of the adsorption heat exchangers (51, 52) has a rectangular thick plate-like shape or a rectangular parallelepiped flattened shape, as a whole. Each of the adsorption heat exchangers (51, 52) is 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).

[0044]

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-side path (31), and the lower space constitutes the exhaust-side path (33).

[0045]

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 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).

[0046]

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-side 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 left side of the center partition plate (73). Further, of the downstream partition plate (72), a portion facing the exhaust-side 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).

[0047]

The eight dampers (41) to (48) constitute a switching mechanism (40) configured to change flow paths of the air.

[0048]

In the casing (11), a space between the front panel portion (12) and the air supply-side

path (31) and exhaust-side 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 (36), and a space on the left side of the partition plate (77) constitutes an exhaust fan compartment (35).

5 [0049]

The air supply fan compartment (36) houses an air supply fan (26). The exhaust fan compartment (35) houses an exhaust fan (25). Both of 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 taken in from beyond the downstream partition plate (72). The exhaust fan (25) is configured to blow out, to the exhaust port (21), the air taken in from beyond the downstream partition plate (72).

[0050]

The air supply fan compartment (36) houses the compressor (53) and the four-way switching valve (54) of the refrigerant circuit (50). 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).

[0051]

<Refrigerant Circuit>

As illustrated in FIGS. 2A and 2B, 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) is filled with a refrigerant, which circulates 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).

25 [0052]

The refrigerant circuit (50) is configured such that the compressor (53) has a discharge pipe connected to a first port of the four-way switching valve (54) and a suction pipe 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 sequentially from a third port to a fourth port of the four-way switching valve (54).

[0053]

The four-way switching valve (54) is switchable between a first state (a state illustrated in FIG. 2A) in which the first and third ports communicate with each other and the second and fourth ports communicate with each other, and a second state (a state illustrated in FIG. 2B) in which the first and fourth ports communicate with each other and the second and third ports communicate with each other.

[0054]

The compressor (53) is a hermetic compressor including a compression mechanism and an electric motor for driving the compression mechanism, which are housed in a 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).

[0055]

<Controller>

The controller (95) illustrated in FIG. 3 is a control device configured to control the

humidity control unit (U) and the refrigerant circuit (50). The controller (95) is connected to the compressor (53), the electrically powered expansion valve (55), the four-way switching valve (54), and the switching mechanism (40) in a wired or wireless manner. The controller (95) is connected to 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) in a wired or wireless manner.

[0056]

The controller (95) has a receiving section configured to receive measurement values of 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). The controller (95) controls the compressor (53), the electrically powered expansion valve (55), the four-way switching valve (54), and the switching mechanism (40). The controller (95) controls the humidity control unit (U) and the refrigerant circuit (50) to switch among various operations.

[0057]

—Operation—

The humidity control apparatus (10) of the present embodiment performs a dehumidifying operation, a humidifying operation, a cooling operation, a heating operation, and a simple ventilating operation. The dehumidifying operation and the humidifying operation are humidity adjusting operations for adjusting the absolute humidity of the outdoor air to be supplied to the indoor space. That is, the dehumidifying operation and the humidifying operation are operations for treating latent heat load (dehumidification load or humidification load) mainly of the indoor space. The cooling operation and the heating operation are sensible heat-treating operations for adjusting the temperature of the outdoor air to be supplied to the indoor space. That is, the cooling operation and the heating operation are operations for treating sensible heat load (cooling load or heating load) mainly of the indoor space. The simple

ventilating operation is an operation simply for ventilating the indoor space.

[0058]

For each of the dehumidifying operation, the humidifying operation, the cooling operation, the heating operation, and the simple ventilating operation, the air supply fan (26) and the exhaust fan (25) are operated. The humidity control apparatus (10) is configured to supply outdoor air (OA) taken therein to the indoor space as the supply air (SA), and exhaust room air (RA) taken therein to the outdoor space (201) as the exhaust air (EA).

[0059]

Hereinafter, the dehumidifying operation and the humidifying operation performed by the humidity control apparatus (10) will be described in detail.

[0060]

<Dehumidifying Operation>

The humidity control apparatus (10) under the dehumidifying operation takes, as first air, the outdoor air via the outdoor air inlet (24) into the casing (11), and takes, as second air, the room air via 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 adjusted. The humidity control apparatus (10) under the dehumidifying operation repeats the first dehumidifying action and the second dehumidifying action (described later) each for several minutes, alternately. In the dehumidifying operation, the execution time of the first dehumidifying action is set to be several minutes. The execution time of the second dehumidifying action is set to be several minutes.

[0061]

As illustrated in FIG. 4, the switching mechanism (40) sets a flow path of the air to a second path in the first dehumidifying 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), the first outdoor air damper (43), the first air supply-side damper (45), and the second exhaust-side damper (48) are closed. In the first dehumidifying action, the four-way switching valve (54) is set to be the first state (the state illustrated in FIG. 2A). The refrigerant circuit (50) performs the refrigeration cycle, in which the first adsorption heat exchanger (51) functions as a radiator, and the second adsorption heat exchanger (52) functions as an evaporator.

[0062]

The first air that has flowed into the outdoor air path (34) flows into the second heat exchanger compartment (38) via the second outdoor air damper (44), and thereafter passes through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (52), the moisture in the first air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The temperature of the first air is lowered to some extent in the second adsorption heat exchanger (52). The first air thus dehumidified by the second adsorption heat exchanger (52) flows into the air supply-side path (31) via the second air supply-side damper (46), and, after passing the air supply fan compartment (36), is supplied to the indoor space via the air supply port (22).

[0063]

The second air that has flowed into the indoor air path (32) flows into the first heat exchanger compartment (37) via the first indoor air damper (41), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption heat exchanger (51), the moisture is desorbed from the adsorbent heated by the refrigerant, and the moisture thus desorbed is added to the second air. The second air thus humidified by the first adsorption heat exchanger (51) flows into the exhaust-side path (33) via the first exhaust-side damper (47), and, after passing the exhaust fan compartment (35), is supplied to the outdoor space (201) via the exhaust port (21).

[0064]

As illustrated in FIG. 5, 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 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. In the second action, the four-way switching valve (54) is set to be the second state (the state illustrated in FIG. 2B). 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.

[0065]

The first air that has flowed into the outdoor air path (34) flows into the first heat exchanger compartment (37) via the first outdoor air damper (43), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption heat exchanger (51), the moisture in the first air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The temperature of the first air is lowered to some extent in the first adsorption heat exchanger (51). The first air thus dehumidified by the first adsorption heat exchanger (51) flows into the air supply-side path (31) via the first air supply-side damper (45), and, after passing the air supply fan compartment (36), is supplied to the indoor space via the air supply port (22).

[0066]

The second air that has flowed into the indoor air path (32) flows into the second heat exchanger compartment (38) via the second indoor air damper (42), and thereafter passes through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (52), the moisture is desorbed from the adsorbent heated by the refrigerant, and the moisture

thus desorbed is added to the second air. The second air thus humidified by the second adsorption heat exchanger (52) flows into the exhaust-side path (33) via the second exhaust-side damper (48), and, after passing the exhaust fan compartment (35), is supplied to the outdoor space (201) via the exhaust port (21).

5 [0067]

<Humidifying Operation>

The humidity control apparatus (10) under the humidifying operation takes, as second air, the outdoor air via the outdoor air inlet (24) into the casing (11), and takes, as first air, the room air via the indoor air inlet (23) into the casing (11). In the refrigerant circuit (50), the
10 compressor (53) operates, and an opening degree of the electrically powered expansion valve (55) is adjusted. The humidity control apparatus (10) under the humidifying operation repeats the first humidifying action and the second humidifying action (described later) alternately. Specifically, in the humidifying operation, the execution time of the first humidifying action is set to be several minutes. The execution time of the second humidifying action is set to be
15 several minutes.

[0068]

As illustrated in FIG. 6, the switching mechanism (40) sets the flow path of the air to the first path in the first humidifying action of the humidifying operation. Specifically, the second indoor air damper (42), the first outdoor air damper (43), the first air supply-side damper
20 (45), and the 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. In the first humidifying action, the four-way switching valve (54) is set to be the first state (the state illustrated in FIG. 2A). The refrigerant circuit (50) performs the refrigeration cycle, in which the first adsorption heat exchanger (51) functions as
25 a condenser (a radiator), and the second adsorption heat exchanger (52) functions as an

evaporator.

[0069]

The first air that has flowed into the indoor air path (32) flows into the second heat exchanger compartment (38) via the second indoor air damper (42), and thereafter passes
5 through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (52), the moisture in the first air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The first air thus dehumidified by the second adsorption heat exchanger (52) flows into the exhaust-side path (33) via the second exhaust-side damper (48), and, after passing the exhaust fan compartment (35), is exhausted to the
10 outdoor space (201) via the exhaust port (21).

[0070]

The second air that has flowed into the outdoor air path (34) flows into the first heat exchanger compartment (37) via the first outdoor air damper (43), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption heat exchanger (51), the moisture
15 is desorbed from the adsorbent heated by the refrigerant, and the moisture thus desorbed is added to the second air. The temperature of the second air increases to some extent in the first adsorption heat exchanger (51). The second air thus humidified by the first adsorption heat exchanger (51) flows into the air supply-side path (31) via the first air supply-side damper (45), and, after passing the air supply fan compartment (36), is supplied to the indoor space via the
20 air supply port (22).

[0071]

As illustrated in FIG. 7, the switching mechanism (40) sets the flow path of the air to the second path in the second humidifying action of the humidifying operation. Specifically, the first indoor air damper (41), the second outdoor air damper (44), the second air supply-side
25 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 set to be the second state (the state illustrated in FIG. 2B). 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.

5 [0072]

The first air that has flowed into the indoor air path (32) flows into the first heat exchanger compartment (37) via the first indoor air damper (41), and thereafter passes through the first adsorption heat exchanger (51). In the first adsorption heat exchanger (51), the moisture

10 in the first air is adsorbed in the adsorbent, and the adsorption heat generated in the adsorption is absorbed by the refrigerant. The first air thus dehumidified by the first adsorption heat exchanger (51) flows into the exhaust-side path (33) via the first exhaust-side damper (47), and, after passing the exhaust fan compartment (35), is exhausted to the outdoor space (201) via the exhaust port (21).

15 [0073]

The second air that has flowed into the outdoor air path (34) flows into the second heat exchanger compartment (38) via the second outdoor air damper (44), and thereafter passes through the second adsorption heat exchanger (52). In the second adsorption heat exchanger (52), the moisture is desorbed from the adsorbent heated by the refrigerant, and the moisture

20 thus desorbed is added to the second air. The temperature of the second air increases to some extent in the second adsorption heat exchanger (52). The second air thus humidified by the second adsorption heat exchanger (52) flows into the air supply-side path (31) via the second air supply-side damper (46), and, after passing the air supply fan compartment (36), is supplied to the indoor space via the air supply port (22).

25 [0074]

<<Features of Embodiment>>

Features of the embodiment will be described in detail.

[0075]

(1) Adsorbent

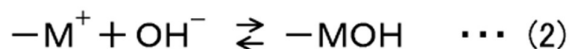
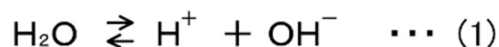
5 In the adsorption heat exchanger (51, 52) serving as an adsorption section, the adsorbent (57) is supported on the heat exchanger (56). An adsorbent (57) of this embodiment includes a metal organic framework that is structurally flexible (hereinafter referred to as a flexible MOF). The flexible MOF is configured to be a material suitable for the adsorption of a target substance by redesigning a combination of a metal ion and an organic ligand (for example,
10 a ligand with a hydrophilic group), an MOF structure and a pore size which are suitable for a target molecular size, and the like. The target substance of the flexible MOF in this embodiment is moisture in the air.

[0076]

 The adsorbent (57) of this embodiment has the property of making water on its surface
15 acidic. When water adheres to the surface of the adsorbent (57), the hydroxy group of the water molecule represented by the formula (1) in the chemical formula 1 reacts with the metal ion (M) of the flexible MOF as shown in the formula (2). In this embodiment, (M) is Al or Zn, for example. In formula (2), the metal ion (M) functions as a Lewis acid. The reaction represented by the formula (2) causes the water on the surface of the adsorbent (57) to have higher hydrogen
20 ion concentration and a lower pH. As a result, the water on the surface of the adsorbent (57) is acidic with a relatively low pH.

[0077]

[Chem. 1]



[0078]

For example, the pH of the water on the surface of the adsorbent (57) using the flexible MOF is 3.3.

5 [0079]

(2) Generation Section

The heat exchanger (56) serves as a generation section of this embodiment. The heat exchanger (56) is a cooling portion configured to cool air so as to generate condensation water. Specifically, the heat exchanger (56) functions as an evaporator, thereby cooling the air to or
10 below a dew point temperature. When condensation water is generated around the heat exchanger (56), the condensation water adheres to the surface of the adsorbent (57). Thus, the water on the surface of the adsorbent (57) becomes acidic as described above.

[0080]

(3) Generation Action

15 The controller (95) causes the heat exchanger (56) to generate condensation water from the air (hereinafter referred to as a generation action).

[0081]

(3-1) Timing of Generation Action in Dehumidifying Operation

In the dehumidifying operation of the humidity control apparatus (10) shown in FIG.
20 8, the controller (95) causes the first action, in which the second adsorption heat exchanger (52) serves as the evaporator, and the second action, in which the second adsorption heat exchanger (52) serves as the radiator, to occur alternately. In the dehumidifying operation of the humidity control apparatus (10), the controller (95) causes the second action, in which the first adsorption

heat exchanger (51) serves as the radiator, and the first action, in which the first adsorption heat exchanger (51) serves as the evaporator, to occur alternately. In other words, in the first dehumidifying action, the controller (95) causes the second action to occur in the first adsorption heat exchanger (51) and the first action to occur in the second adsorption heat exchanger (52) at the same time. In the second dehumidifying action, the controller (95) causes the first action to occur in the first adsorption heat exchanger (51) and the second action to occur in the second adsorption heat exchanger (52) at the same time.

[0082]

The controller (95) causes the generation action to occur in the first action of each of the adsorption heat exchangers (56). Specifically, in the first dehumidifying action, the controller (95) causes the generation action to occur in the first action of the second adsorption heat exchanger (52). In the second dehumidifying action, the controller (95) causes the generation action to occur in the first action of the first adsorption heat exchanger (51).

[0083]

The controller (95) causes the generation action to occur in the first action from a time point t_1 to a time point t_2 . The time point t_1 corresponds to the time point when the first action ends. The time point t_1 corresponds to the time point that precedes the time point t_2 by ΔT_1 . The execution time (ΔT_1) of the generation action in the dehumidifying operation is set to a value obtained by multiplying the execution time of the first action by $\alpha\%$. Here, α is determined according to the characteristics (adsorption isotherm) of the adsorbent (57), the operating conditions of the dehumidifying operation, and the like.

[0084]

(3-2) Timing of Generation Action in Humidifying Operation

In the humidifying operation of the humidity control apparatus (10) shown in FIG. 9, the controller (95) causes the first action, in which the second adsorption heat exchanger (52)

serves as the evaporator, and the second action, in which the second adsorption heat exchanger (52) serves as the radiator, to occur alternately. In the humidifying operation of the humidity control apparatus (10), the controller (95) causes the second action, in which the first adsorption heat exchanger (51) serves as the radiator, and the first action, in which the first adsorption heat exchanger (51) serves as the evaporator, to occur alternately. In other words, in the first humidifying action, the controller (95) causes the second action to occur in the first adsorption heat exchanger (51) and the first action to occur in the second adsorption heat exchanger (52) at the same time. In the second humidifying action, the controller (95) causes the first action to occur in the first adsorption heat exchanger (51) and the second action to occur in the second adsorption heat exchanger (52) at the same time.

[0085]

The controller (95) causes the generation action to occur in the first action of each of the adsorption heat exchangers (56). Specifically, in the first humidifying action, the controller (95) causes the generation action to occur in the first action of the second adsorption heat exchanger (52). In the second humidifying action, the controller (95) causes the generation action to occur in the first action of the first adsorption heat exchanger (51).

[0086]

The controller (95) causes the generation action to occur in the first action from a time point t_3 to a time point t_4 . The time point t_4 corresponds to the time point when the first action ends. The time point t_4 corresponds to the time point that precedes the time point t_3 by ΔT_2 . The execution time (ΔT_2) of the generation action in the humidifying operation is set to a value obtained by multiplying the execution time of the first action by $\beta\%$. Here, β is determined according to the characteristics (adsorption isotherm) of the adsorbent (57), the operating conditions of the humidifying operation, and the like.

[0087]

(3-3) Specific Control of Generation Action

When the first action starts, the controller (95) controls the evaporation temperature of the adsorption heat exchanger (56) (heat exchanger (57)) so that the temperature of the air flowing through the adsorption heat exchanger (56) be a predetermined temperature higher than a dew point temperature. The controller (95) adjusts the number of revolutions of the compressor (53), thereby controlling the evaporation temperature of the heat exchanger (56).

[0088]

The dew point temperature of the air flowing through the adsorption heat exchanger (56) can be obtained from measurement values of the temperature sensor and the humidity sensor. Specifically, the controller (95) obtains the dew point temperature of the outdoor air (OA) based on the measurement value of the outdoor air temperature sensor (93) and the measurement value of the outdoor air humidity sensor (94) when the outdoor air (OA) is sent to the adsorption heat exchanger (56). The controller (95) obtains the dew point temperature of the room air (RA) based on the measurement value of the indoor air temperature sensor (91) and the measurement value of the indoor air humidity sensor (92) when the room air (RA) is sent to the adsorption heat exchanger (56).

[0089]

In the first action, moisture in the air is adsorbed by the adsorbent (57) until the execution of the generation action. Then, when the generation action is executed, the controller (95) controls the evaporation temperature of the heat exchanger (57) so that the temperature of the air flowing through the adsorption heat exchanger (56) be lower than or equal to a dew point temperature. As a result, condensation water is generated from the air. The condensation water generated adheres to the surface of the adsorbent (57).

[0090]

As mentioned above, the adsorbent (57) has the property of making water on its surface

acidic. Accordingly, the water on the surface of the adsorbent (57) can be made acidic, thereby making it possible to reduce the multiplication of microorganisms on the adsorbent (57).

[0091]

(4) Relationship between Multiplication of Microorganisms and pH

FIG. 10 shows types of microorganisms and ranges of the pH for the growth of the microorganisms. The “OPTIMAL GROWTH RANGE” is the pH range suitable for the growth of the respective microorganism. If the pH is within this range, the multiplication of the microorganism is encouraged. The “CRITICAL GROWTH RANGE” is the pH range in which the microorganism can grow. If the pH is outside this range, the microorganisms cannot survive.

[0092]

The adsorbent (57) has the property of making water on its surface have the pH of 5 or less in one preferred embodiment. This makes it possible to reduce the multiplication of general bacteria on the surface of the adsorbent (57) effectively.

[0093]

The adsorbent (57) has the property of making water on its surface have the pH of a range between 2 and 4 in one preferred embodiment. This makes it possible to reduce the multiplication of each of mold, yeast, general bacteria, and Spanish influenza virus on the surface of the adsorbent (57) effectively.

[0094]

The adsorbent (57) has the property of making water on its surface have the pH of less than 2 in one preferred embodiment. This makes it possible to reduce the generation itself of each of mold, yeast, general bacteria, and Spanish influenza virus on the surface of the adsorbent (57).

[0095]

(5) Advantages of Embodiment

The adsorbent (57) has the property of making water on its surface acidic. Accordingly, the water on the surface of the adsorbent (57) can be made acidic, thereby making it possible to reduce the multiplication of microorganisms. It is not necessary to provide another device for sterilizing the adsorbent (57), and the adsorption system can be simplified.

5 [0096]

The generation section is a cooling portion (heat exchanger (56)) configured to generate condensation water in the air. It is thus possible to generate water on the surface of the adsorbent (57) without a device that supplies water to the adsorbent (57).

[0097]

10 The heat exchanger (56) generates condensation water on the surface of the adsorbent (57) every time the first action is executed. Accordingly, the water on the surface of the adsorbent (57) can be maintained acidic, thereby making it possible to reduce the multiplication of microorganisms reliably.

[0098]

15 In addition, the controller (95) causes the generation action to occur immediately before the end of the first action. Accordingly, sufficient moisture can be adsorbed on the adsorbent (57) in the first action until the execution of the generation action.

[0099]

<<Variations of Embodiment>>

20 The above embodiment may be modified as follows.

[0100]

<Variation 1 – Adsorption Section>

The adsorption section of the embodiment is a type in which the heat exchanger (56) has the adsorbent (57). However, the adsorption section may be a rotor type in which a rotatable
25 rotor has the adsorbent (57) on its surface, or may be an adsorption element type in which a

base material through which air can pass has the adsorbent (57) on its surface. In these embodiments, a cooling portion for cooling air is disposed on the upstream side of the adsorption section of the rotor type or the adsorption element type. The cooling portion cools the air to below the dew point temperature, which allows water to adhere to the surface of the adsorbent (57).

[0101]

<Variation 2 – Cooling Portion>

The cooling portion may be other than the heat exchanger (56) functioning as an evaporator. The cooling portion may be a heat exchanger through which cold water or brine flows, or a thermoelectric element such as a Peltier element.

[0102]

<Variation 3 – Generation Section>

The generation section may be a means for supplying water to the adsorbent (57). For example, the generation section may include a water pipe and a sprayer that sprays, onto the adsorbent (57), water which has flowed through the water pipe.

[0103]

<Variation 4 – Adsorbent>

The adsorbent (57) may contain materials other than the metal organic framework.

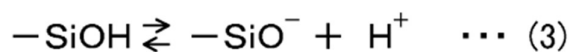
[0104]

(Variation 4-1)

The adsorbent (57) may contain silica gel. Silica gel has the property of generating a hydrogen ion from a silanol group ($-\text{SiOH}$) in the presence of surrounding water, as shown in formula (3) of the chemical formula 2. Thus, when water adheres to the surface of the adsorbent (57), the water becomes acidic. It is therefore possible to reduce the multiplication of microorganisms on the surface of the adsorbent (57).

[0105]

[Chem. 2]



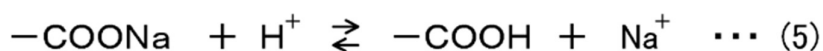
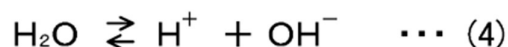
[0106]

5 (Variation 4-2)

The adsorbent (57) may contain sodium polyacrylate. When water adheres to the surface of the adsorbent (57), the hydrogen ion of the water molecule represented by formula (4) of chemical formula 3 reacts with the sodium salt of the carboxyl group (-COONa), as shown in formula (5), resulting in a high hydroxide ion concentration. As a result, the water on
10 the surface of the adsorbent (57) is alkaline with a relatively high pH.

[0107]

[Chem. 3]



[0108]

15 As shown in FIG. 10, mold, yeast, general bacteria, Spanish influenza virus, and the like each have the optimal growth range and critical growth range of pH on the acidic side. It is thus possible to reduce the multiplication of microorganisms by making the pH of the water on the surface of the adsorbent (57) alkaline.

[0109]

20 The adsorbent (57) has the property of making water on its surface have the pH of 9 or more in one preferred embodiment. This makes it possible to further reduce the multiplication of microorganisms on the surface of the adsorbent (57).

[0110]

<Variation 5 – Timing of Generation Action>

The timing of the generation action for generating water on the surface of the adsorbent (57) is not necessarily immediately before the end of the first action. The controller (95) may cause the generation action to occur at the end of an operation of the humidity control apparatus (10) including a dehumidifying operation and a humidifying operation, for example. The controller (95) may cause the generation action to occur at the start of an operation of the humidity control apparatus (10) including a dehumidifying operation and a humidifying operation, for example.

10 [0111]

<Variation 6 – Target Substance>

The target substance of the adsorbent (57) may be other than water in the air, such as carbon dioxide, volatile organic compounds (VOCs), or other malodorous substances.

[0112]

15 It will be understood that the embodiments and variations described above can be modified with various changes in form and details without departing from the spirit and scope of the claims. The embodiments and variations described above may be appropriately combined or modified by replacing the elements thereof, as long as the functions of the subject matters of the present disclosure are not impaired.

20 [0113]

The ordinal numbers such as “first,” “second,” “third,” . . . , 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.

25 INDUSTRIAL APPLICABILITY

[0114]

As described above, the present disclosure is useful as an adsorption system.

DESCRIPTION OF REFERENCE CHARACTERS

5 [0115]

10 Humidity Control Apparatus (Adsorption System)

51 First Adsorption Heat Exchanger (Adsorption Section)

52 Second Adsorption Heat Exchanger (Adsorption Section)

56 Heat Exchanger (Cooling Portion, Generation Section)

10 57 Adsorbent

95 Controller (Control Device)

CLAIMS

1. An adsorption system, comprising:
an adsorption section (51, 52) having an adsorbent (57) that adsorbs a target substance;
5 and
a generation section (56) configured to generate water on a surface of the adsorbent (57),
the adsorbent (57) having a property of making the water on the surface acidic or alkaline.
10
2. The adsorption system of claim 1, wherein
the generation section includes a cooling portion (56) configured to cool air so as to generate condensation water.
- 15 3. The adsorption system of claim 2, wherein
the adsorption section (51, 52) includes a heat exchanger (56) having the adsorbent (57), and
the cooling portion is the heat exchanger (56) functioning as an evaporator.
- 20 4. The adsorption system of claim 3, further comprising:
a control device (95) configured to cause a first action in which the heat exchanger (56) functions as an evaporator and a second action in which the heat exchanger (56) functions as a radiator to occur alternately, wherein
the heat exchanger (56) cools the air in the first action so as to generate the
25 condensation water.

5. The adsorption system of any one of claims 1 to 4, wherein
the adsorbent (57) has a property of making the water on the surface acidic with a
Lewis acid.
- 5
6. The adsorption system of any one of claims 1 to 4, wherein
the adsorbent (57) includes a metal organic framework.
7. The adsorption system of any one of claims 1 to 4, wherein
the adsorbent (57) includes silica gel.
- 10
8. The adsorption system of any one of claims 1 to 4, wherein
the adsorbent (57) includes sodium polyacrylate.
- 15
9. The adsorption system of any one of claims 1 to 4, wherein
the adsorbent (57) has a property of making the water on the surface have a pH of 5 or
less or 9 or more.
10. The adsorption system of claim 9, wherein
the adsorbent (57) has a property of making the water on the surface have a pH of a
range between 2 and 4.
- 20
11. The adsorption system of claim 9, wherein
the adsorbent (57) has a property of making the water on the surface have a pH of less
than 2.
- 25