DESCRIPTION

INSIDE AIR CONTROL SYSTEM

TECHNICAL FIELD

[0001]

The present disclosure relates to an inside air control system.

BACKGROUND ART

[0002]

Patent Document 1 discloses an inside air control system that controls the composition of inside air in a storage, such as a shipping container. To keep vegetables, fruits, and other items stored in the storage fresh, this inside air control system mainly controls the oxygen concentration and carbon dioxide concentration of the inside air. This inside air control system includes an oxygen sensor and a carbon dioxide sensor as gas sensors each of which measures the concentration of an associated gas contained in the inside air. The oxygen sensor measures the oxygen concentration of the inside air. The carbon dioxide sensor measures the carbon dioxide concentration of the inside air. Thus, this inside air control system controls the composition of the inside air using measured values measured by the sensors.

CITATION LIST

PATENT DOCUMENT

[0003]

Patent Document 1: Japanese Unexamined Patent Publication No. 2018-148877

FIG. 4 is a schematic cross-sectional view of a separation module of an inside air control system according to an embodiment.

FIG. 5 is a block diagram showing a configuration of a controller of an inside air control system according to an embodiment.

FIG. 6 is a piping system diagram of an inside air control system showing a state of the inside air control system that is performing an oxygen concentration increasing operation according to an embodiment.

FIG. 7 is a piping system diagram of an inside air control system showing a state of a first composition controller that is performing a first operation according to an embodiment.

FIG. 8 is a piping system diagram of an inside air control system showing a state of a first composition controller that is performing a second operation according to an embodiment.

FIG. 9 is a piping system diagram of an inside air control system showing a state of a first composition controller that is performing an outdoor air supply operation according to an embodiment.

FIG. 10 is a flowchart showing a sensor abnormality handling operation performed by a controller of an inside air control system according to an embodiment.

DESCRIPTION OF EMBODIMENTS

[0027]

Embodiments of the present invention will be described in detail with reference to the drawings. An inside air control system (30) according to this embodiment is installed in a shipping container (1) to provide so-called controlled atmosphere (CA) transportation. The inside air control system (30) controls the composition of air in the shipping container (1) such that the composition of the air therein is different from that of the atmosphere.

separation module (61) than the other end of the second bypass pipe (71) connected to the primary pipe (73) is. The pressure sensor (65) is disposed closer to the separation module (61) than the regulating valve (66) is.

[0082]

The pressure sensor (65) measures the pressure of the second type of inside air that has flowed out of the primary exhaust port (63) of the separation module (61). The measured value obtained by the pressure sensor (65) is substantially equal to the pressure of the untreated inside air supplied to the separation module (61) by the pump body (37).

[0083]

The regulating valve (66) is a motor-operated valve with a variable opening degree, and constitutes a second valve mechanism. Changing the opening degree of the regulating valve (66) triggers a change in the pressure of the untreated inside air supplied to the separation module (61) by the pump body (37).

[0084]

—Second Separation Module—

The separation module (61) will be described with reference to FIG. 4.

[0085]

The separation module (61) includes one cylindrical case (80) and two partition walls (81a, 81b). The cylindrical case (80) is an elongated cylindrical container with both ends closed. The partition walls (81a, 81b) are members for partitioning the internal space of the cylindrical case (80), and cross the internal space of the cylindrical case (80). The partition walls (81a, 81b) are respectively arranged near two ends of the internal space of the cylindrical case (80). In FIG. 4, the internal space of the cylindrical case (80) is partitioned into an introduction chamber (82) located on the left side of the left partition wall (81a), a secondary exhaust chamber (84) located between the two partition walls (81a, 81b), and a

also as a concentration control operation for controlling the concentration of carbon dioxide as a target gas contained in the inside air.

[0111]

The composition of the inside air present in the cargo space (5) at the point in time when loading of the shipping container (1) with the cargos (6) is completed is substantially the same as the composition of the atmosphere (nitrogen concentration: 78%, oxygen concentration: 21%, carbon dioxide concentration: 0.04%). To address this situation, the inside air control system (30) performs the oxygen concentration lowering operation for reducing the oxygen concentration of the inside air. If the oxygen concentration of the inside air reaches the upper limit (6%) of the associated target range, the inside air control system (30) stops the oxygen concentration lowering operation.

[0112]

After the oxygen concentration of the inside air has reached 6%, and the inside air control system (30) has stopped the oxygen concentration lowering operation, breathing of the plants, which are the cargos (6), gradually reduces the oxygen concentration of the inside air, and simultaneously and gradually increases the carbon dioxide concentration of the inside air.

[0113]

If the carbon dioxide concentration of the inside air reaches the upper limit (3%) of the associated target range, the inside air control system (30) performs the carbon dioxide concentration lowering operation to reduce the carbon dioxide concentration of the inside air. If the carbon dioxide concentration of the inside air reaches the lower limit (1%) of the associated target range, the inside air control system (30) stops the carbon dioxide concentration lowering operation.

[0114]

If the oxygen concentration of the inside air reaches the lower limit (4%) of the

associated target range, the inside air control system (30) performs the oxygen concentration increasing operation to raise the oxygen concentration of the inside air. If the oxygen concentration of the inside air reaches the upper limit (6%) of the associated target range, the inside air control system (30) stops the oxygen concentration increasing operation.

[0115]

As can be seen, the inside air control system (30) performs the oxygen concentration lowering operation to reduce the oxygen concentration of the inside air in the cargo space (5) from 21% (the oxygen concentration of the atmosphere) to the target range. The inside air control system (30) repeatedly performs the carbon dioxide concentration lowering operation and the oxygen concentration increasing operation as appropriate to maintain the oxygen concentration and carbon dioxide concentration of the inside air in the cargo space (5) within the respective target ranges.

[0116]

‹Oxygen Concentration Lowering Operation›

The oxygen concentration lowering operation of the inside air control system (30) will be described with reference to FIG. 3. In the oxygen concentration lowering operation, the first composition controller (40) supplies the first type of outside air with a low oxygen concentration to the cargo space (5), and the second composition controller (60) supplies the first type of inside air with a low oxygen concentration to the cargo space (5).

[0117]

In the oxygen concentration lowering operation, the controller (110) makes the first composition controller (40) alternately and repeatedly execute a first operation and a second operation, which will be described below. The operation of the first composition controller (40) will be described below in detail. In the oxygen concentration lowering operation, the controller (110) places the second bypass valve (70) in a first state (the state indicated by the

to the outside of the shipping container (1) to reduce the oxygen concentration of the inside air in the cargo space (5).

[0124]

‹Carbon Dioxide Concentration Lowering Operation›

The carbon dioxide concentration lowering operation of the inside air control system (30) will be described with reference to FIG. 3. In the carbon dioxide concentration lowering operation, each of the first and second composition controllers (40) and (60) performs an operation similar to the oxygen concentration lowering operation. In the carbon dioxide concentration lowering operation, the first composition controller (40) supplies the first type of outside air with a low oxygen concentration to the cargo space (5), and the second composition controller (60) supplies the first type of inside air with a low carbon dioxide concentration to the cargo space (5).

[0125]

The first composition controller (40) separates untreated outside air that has flowed into the first separator (41) described below into the first type of outside air having a higher nitrogen concentration and a lower oxygen concentration than the untreated outside air, and the second type of outside air having a lower nitrogen concentration and a higher oxygen concentration than the untreated outside air. Then, the first type of outside air is supplied into the shipping container (1), and the second type of outside air is discharged to the outside of the shipping container (1). The carbon dioxide concentration of the untreated outside air is substantially the same as the carbon dioxide concentration (0.04%) of the atmosphere. Thus, the carbon dioxide concentration of the first type of outside air can be assumed to be substantially zero.

[0126]

The second composition controller (60) separates untreated inside air that has flowed

is placed in the first state, and the second directional control valve (233) is placed in the second state. As a result, the blowout port of the first pump mechanism (231a) is connected to the first adsorption column (234), and the second adsorption column (235) is connected to the intake port of the second pump mechanism (231b). In the first operation, the supply on-off valve (273) is opened, and the remaining on-off valves (251, 256, 272, 282) are closed. In the first operation, an adsorption operation for the first adsorption column (234) and a desorption operation for the second adsorption column (235) are performed.

[0138]

The first pump mechanism (231a) sucks untreated outside air from the outdoor air pipe (241), compresses the sucked untreated outside air, and supplies the compressed untreated outside air to the first adsorption column (234). Nitrogen contained in the untreated outside air supplied to the first adsorption column (234) is adsorbed on the adsorbent. As a result, the first adsorption column (234) produces the second type of outside air having a lower nitrogen concentration and a higher oxygen concentration than the untreated outside air. The second type of outside air flows out of the first adsorption column (234), flows through the oxygen discharge pipe (245), and is discharged, as discharge air, to a space outside the shipping container (1).

[0139]

In contrast, the second pump mechanism (231b) sucks the air from the second adsorption column (235). The second adsorption column (235) has its internal pressure reduced, and nitrogen is thus desorbed from the adsorbent. As a result, the second adsorption column (235) produces the first type of outside air having a higher nitrogen concentration and a lower oxygen concentration than the untreated outside air. The first type of outside air flows from the second adsorption column (235) into the suction pipe (243), and is sucked into the second pump mechanism (231b). The second pump mechanism (231b) compresses the sucked

[Step ST2]

In step ST2, the sensor abnormality handler (117) disables the carbon dioxide concentration lowering operation of the inside air control system (30). If either the first or second condition is satisfied, the measured value obtained by the carbon dioxide sensor (92) can be estimated to be different from the actual carbon dioxide concentration of the inside air. Thus, in this case, the sensor abnormality handler (117) disables the carbon dioxide concentration lowering operation. Even if the measured value obtained by the carbon dioxide sensor (92) falls outside the target carbon dioxide concentration range while the sensor abnormality handler (117) disables the carbon dioxide concentration lowering operation, the air composition control unit (115) prevents the inside air control system (30) from executing the carbon dioxide concentration lowering operation.

[0164]

In contrast, in this step ST2, the oxygen concentration lowering operation and the oxygen concentration increasing operation of the inside air control system (30) are not disabled. Thus, even after the sensor abnormality handler (117) has disabled the carbon dioxide concentration lowering operation, the air composition control unit (115) continues to perform an operation for controlling the oxygen concentration of the inside air based on the measured value obtained by the oxygen sensor (91). Specifically, if the value measured by the oxygen sensor (91) falls outside the target range of the oxygen concentration, the air composition control unit (115) instructs the inside air control system (30) to execute the oxygen concentration lowering operation or the oxygen concentration increasing operation so that the measured value obtained by the oxygen sensor (91) falls within the target range.

[0165]

In step ST2, the sensor abnormality handler (117) issues an alarm indicating that an abnormality has occurred in the carbon dioxide sensor (92). The alarm is issued to notify an operator who manages and maintains the container refrigerator (10) of an abnormality in the

carbon dioxide sensor (92). Examples of the alarm include illumination of a warning light provided on an operating section of the container refrigerator (10), and a warning displayed on a liquid crystal display screen provided on the operating section.

[0166]

[Step ST3]

In the next step ST3, the sensor abnormality handler (117) determines whether or not a third condition has been satisfied. The third condition is a condition where "the state in which the measured value φ_CO2 obtained by the carbon dioxide sensor (92) is above −1.5% and below 20.0% (−1.5% < φ_CO2 < 20.0%) continues for one minute." The third condition is a condition indicating that the measured value obtained by the carbon dioxide sensor (92) falls within the normal range.

[0167]

For example, if condensation on the carbon dioxide sensor (92) causes the measured value obtained by the carbon dioxide sensor (92) to fall outside the normal range, the lapse of a certain period of time reduces the amount of water droplets that have adhered to the carbon dioxide sensor (92), and the value measured by the carbon dioxide sensor (92) thus returns to the normal range. If the measured value obtained by the carbon dioxide sensor (92) returns to the normal range after falling outside the normal range, the carbon dioxide sensor (92) itself is highly likely not to be damaged.

[0168]

Thus, if the third condition is satisfied in step ST3, the sensor abnormality handler (117) determines that the carbon dioxide sensor (92) may continue to be used, and the process proceeds to step ST4. On the other hand, if the third condition is not satisfied in step ST3, the carbon dioxide sensor (92) is highly likely to be damaged. Thus, in this case, the sensor abnormality handler (117) continues the disabling of the carbon dioxide concentration lowering operation

[0175]

[Step ST7]

At the end of step ST6, the carbon dioxide sensor (92) has been determined to have functioned normally, and calibration of the carbon dioxide sensor (92) has been completed. Thus, in step ST7, the sensor abnormality handler (117) allows the carbon dioxide concentration lowering operation of the inside air control system (30) disabled in step ST2. If the measured value obtained by the carbon dioxide sensor (92) falls outside the target range of the carbon dioxide concentration while the sensor abnormality handler (117) allows the carbon dioxide concentration lowering operation, the air composition control unit (115) instructs the inside air control system (30) to execute the carbon dioxide concentration lowering operation. The sensor abnormality handler (117) cancels the alarm issued in step ST2. Completion of the operation of step ST7 allows the sensor abnormality handler (117) to terminate the sensor abnormality handling operation.

[0176]

[Step ST8]

As described above, if the fourth condition is not satisfied in step ST5, the sensor determiner (118) determines that the carbon dioxide sensor (92) is not normal. In this case, the sensor abnormality handler (117) allows the process to proceed to step ST8, and determines whether or not a re-determination condition has been satisfied. When allowing the process to proceed to step ST8, the sensor abnormality handler (117) instructs the inside air control system (30) to stop the outdoor air supply operation.

[0177]

If the re-determination condition is not satisfied, the sensor abnormality handler (117) allows the process to remain in step ST8. While the process remains in step ST8, the sensor abnormality handler (117) disables the carbon dioxide concentration lowering operation of the inside air control system (30), and maintains the issued alarm. On the other

normal range, the controller (110) of the inside air control system (30) according to this embodiment stops the concentration control operation (in this embodiment, the carbon dioxide concentration lowering operation). If the measured value obtained by the gas sensor (92) falls outside the predetermined normal range, the controller (110) according to this embodiment stops the concentration control operation of the inside air control system (30). This can avoid the concentration control operation based on an incorrect measured value obtained by the gas sensor (92).

[0191]

—Feature (5) of Embodiment—

If the controller (110) of the inside air control system (30) according to this embodiment determines in the determination operation that the gas sensor (92) is not normal, the controller (110) temporarily stops supply of outdoor air to the gas sensor (92). If a predetermined re-determination condition is thereafter satisfied, the controller (110) again performs the determination operation.

[0192]

If the controller (110) of the inside air control system (30) according to this embodiment determines in the determination operation that the gas sensor (92) is not normal, the controller (110) temporarily stops supply of outdoor air to the gas sensor (92). If the re-determination condition is thereafter satisfied, the controller (110) again performs the determination operation. As described above, some of the causes why the measured value obtained by the gas sensor (92) falls outside the predetermined normal range are eliminated after a lapse of a certain period of time. Thus, even if the controller (110) determines in the determination operation that the gas sensor (92) is not normal, the determination operation again performed later may allow a determination to be made that the gas sensor (92) is normal. Thus, according to this embodiment, the determination operation again performed can