

DESCRIPTION

TITLE

REFRIGERATION DEVICE FOR CONTAINER

5

TECHNICAL FIELD

[0001]

The present disclosure relates to a container refrigeration apparatus.

BACKGROUND ART

10 [0002]

Patent Document 1 discloses a container refrigeration apparatus. The container refrigeration apparatus is applied to a container that transports an object, such as food, and performs a cooling operation of cooling the inside of the container. Paragraph [0099] of Patent Document 1 discloses the following: when the temperature inside the refrigerator reaches a
15 predetermined temperature through a cooling operation, the compressor stops and the ventilator performs an operation of introducing outside air into the container.

CITATION LIST

PATENT DOCUMENT

20 [0003]

Patent Document 1: Japanese Patent No. 4609590

SUMMARY OF THE INVENTION

TECHNICAL PROBLEMS

25 [0004]

In the container refrigeration apparatus of Patent Document 1, the ventilator performs a ventilating operation to supply outside air into the container. Once the ventilating operation is performed, the temperature of the inside air changes due to the introduction of the outside air into the container. As a result, control of the temperature of the object is compromised.

5 [0005]

It is an object of the present disclosure to reduce a change in the temperature of inside air in accordance with a ventilating operation.

SOLUTION TO THE PROBLEMS

10 [0006]

A first aspect is directed to a container refrigeration apparatus. The container refrigeration apparatus includes: a cooling unit (10A) including a compressor (25), a radiator (26), an expansion mechanism (31), and an evaporator (29) and being configured to perform, by the evaporator (29), a cooling operation of cooling an inside of a container (1); a ventilator (40) configured to supply outside air into the container (1); and a control unit (100) configured to control the cooling unit (10A) and the ventilator (40). The control unit (100) adjusts a cooling capability of the cooling unit (10A), based on a ventilation cooling load in accordance with a ventilating operation of the ventilator (40).

[0007]

20 In the first aspect, the control unit (100) adjusts the cooling capability of the cooling unit (10A), based on the ventilation cooling load in accordance with the ventilating operation of the ventilator (40). Accordingly, with an increase in the cooling load of the cooling unit (10A) in accordance with the ventilating operation, the cooling capability increases in accordance with this cooling load. As a result, a change in the temperature of the inside air in accordance with
25 the ventilating operation can be reduced.

[0008]

A second aspect is an embodiment of the first aspect. In the second aspect, the control unit (100) controls the ventilator (40) so that an amount of ventilation by the ventilator (40) approaches a first ventilation amount. The control unit (100) adjusts the cooling capability of the cooling unit (10A), based on an internal cooling load that is a cooling load inside the container and the ventilation cooling load according to the first ventilation amount.

[0009]

In the second aspect, the ventilator (40) performs the ventilating operation with the first ventilation amount regarded as the target value. In the cooling unit (10A), the control unit (100) adjusts the cooling capability of the cooling unit (10A), based on the internal cooling load that is the cooling load inside the container and the ventilation cooling load according to the first ventilation amount. This can reduce a change in the temperature of the inside air due to the change in the amount of ventilation by the ventilator (40) to the first ventilation amount.

[0010]

A third aspect is an embodiment of the second aspect. In the third aspect, the control unit (100) executes first control of determining a first cooling capability of the cooling unit (10A), based on the internal cooling load and the ventilation cooling load according to the first ventilation amount, second control of causing the amount of ventilation by the ventilator (40) to approach the first ventilation amount after the first control; and third control of causing the cooling capability of the cooling unit (10A) to approach the first cooling capability after the first control.

[0011]

In the third aspect, in the first control, the first cooling capability is determined based on the internal cooling load and the ventilation cooling load according to the first ventilation amount. In the second control after the first control, the amount of ventilation by the ventilator

(40) approaches the first ventilation amount. In the third control after the first control, the cooling capability approaches the first cooling capability. As a result, when the amount of ventilation by the ventilator (40) reaches the first ventilation amount, the cooling capability is likely to reach the first cooling capability already. This can reduce a change in the temperature of the inside air due to the change in the amount of ventilation by the ventilator (40) to the first ventilation amount.

[0012]

A fourth aspect is an embodiment of any one of the first to third aspects. In the fourth aspect, the control unit (100) performs a first limiting operation of limiting a rate of change in an amount of ventilation by the ventilator (40) so that an index indicating a rate of change in the cooling capability of the cooling unit (10A) in accordance with the ventilating operation of the ventilator (40) is lower than or equal to a predetermined value.

[0013]

With a large change in the first cooling load in accordance with the ventilating operation of the ventilator (40), the rate of change in the cooling capability of the cooling unit (10A) may exceed the limit range, which causes failure to reduce a change in the temperature of the inside air. The control unit (100) limits the rate of change in the amount of ventilation by the ventilator (40) so that the index indicating the rate of change in the cooling capability of the cooling unit (10A) in accordance with the ventilating operation of the ventilator (40) is lower than or equal to the predetermined value. This can reduce the failure of the cooling capability of the cooling unit (10A) in following the change in the second cooling load in accordance with the ventilating operation. As a result, a change in the temperature of the inside air can be reduced.

[0014]

A fifth aspect is an embodiment of the fourth aspect. In the fifth aspect, the control unit (100) executes the first limiting operation when a first mode is selected through an operation of

an operation unit (110).

[0015]

In the fifth aspect, the user or any suitable person can select whether to execute the first limiting operation by operating the operation unit (110).

5 [0016]

A sixth aspect is an embodiment of any one of the first to fifth aspects. In the sixth aspect, the control unit (100) controls the ventilator (40), based on the cooling capability of the cooling unit (10A).

[0017]

10 In the sixth aspect, the ventilator (40) is controlled based on the cooling capability of the cooling unit (10A).

[0018]

A seventh aspect is an embodiment of the sixth aspect. In the seventh aspect, the control unit (100) performs a second limiting operation of limiting an amount of ventilation by the ventilator (40) when an index indicating the cooling capability of the cooling unit (10A) is greater than a predetermined value.

15 [0019]

In the seventh aspect, the amount of ventilation by the ventilator (40) is limited at a high cooling capability of the cooling unit (10A), which can reduce a failure of the cooling unit (10A) in processing the second cooling load in accordance with the ventilating operation.

20 [0020]

An eighth aspect is an embodiment of the seventh aspect. In the eighth aspect, the control unit (100) performs the second limiting operation when a second mode is selected through an operation of an operation unit (110).

25 [0021]

In the eighth aspect, the user or any suitable person can select whether to execute the second limiting operation by operating the operation unit (110).

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0022]

[FIG. 1] FIG. 1 is a perspective view of a container refrigeration apparatus according to an embodiment as viewed from front.

[FIG. 2] FIG. 2 is a vertical cross-sectional view of the container refrigeration apparatus.

10 [FIG. 3] FIG. 3 is a piping system diagram of the container refrigeration apparatus.

[FIG. 4] FIG. 4 is a schematic front view of a ventilator. In FIG. 4, (A) shows a lid in a closed position, (B) shows the lid in an intermediate position, and (C) shows the lid in a fully open position.

[FIG. 5] FIG. 5 is a block diagram of main devices of the container refrigeration
15 apparatus.

[FIG. 6] FIG. 6 is a flowchart for explaining switching among a usual mode, a ventilation load reduction mode, and a cooling priority mode in a cooling operation.

[FIG. 7] FIG. 7 is a flowchart for explaining control in the usual mode.

[FIG. 8] FIG. 8 is a flowchart for explaining control in the ventilation load reduction
20 mode.

[FIG. 9] FIG. 9 is a flowchart for explaining control in the cooling priority mode.

DESCRIPTION OF EMBODIMENTS

[0023]

25 Embodiments of the present disclosure will be described in detail below with reference

to the drawings. The present disclosure is not limited to the embodiments shown below, and various changes can be made within the scope without departing from the technical concept of the present disclosure. Since each of the drawings is intended to illustrate the present disclosure conceptually, dimensions, ratios, or numbers may be exaggerated or simplified as necessary for ease of understanding.

[0024]

(1) Overall Configuration of Container Refrigeration Apparatus

A container refrigeration apparatus (10) will be described. In the following description, the terms for directions such as “front,” “back,” “upper,” “lower,” “right,” and “left” refer to the directions of the arrows in FIG. 1.

[0025]

As shown in FIGS. 1 and 2, the container refrigeration apparatus (10) is provided in a container (1). The container (1) is used for marine transportation. The container (1) is a refrigeration container that cools the inside air. The container (1) includes a container body (2) and the container refrigeration apparatus (10). The container body (2) stores objects, such as food and plants. The container refrigeration apparatus (10) cools the air in the internal space (3) of the container body (2). As shown in FIG. 2, a front opening (4) is open in the front surface of the container body (2). The container refrigeration apparatus (10) is attached to the container body (2) so as to close the front opening (4) of the container body (2).

[0026]

As shown in FIG. 5, the container refrigeration apparatus (10) includes a cooling unit (10A) for cooling the internal space (3), and a ventilator (40) for ventilating the internal space (3).

[0027]

(2) Cooling Unit

As shown in FIGS. 1 and 2, the cooling unit (10A) includes a casing (11). The casing (11) forms a lid of the front opening (4) of the container body (2). The casing (11) includes a casing body (12) and a partition plate (13). The casing body (12) separates the internal space (3) from an external space (5) outside the container body (2). The partition plate (13) is located at the back (i.e., the rear) of the casing (11).

[0028]

The cooling unit (10A) includes a compressor (25), an external heat exchanger (26), and an external fan (27) as devices located outside. The cooling unit (10A) includes an internal heat exchanger (29) and an internal fan (30) as devices disposed inside.

10 [0029]

(2-1) Casing Body

As shown in FIG. 2, the casing body (12) includes a flat-plate portion (12a) and a recessed portion (12b). The flat-plate portion (12a) is an upper part of the casing body (12) that is substantially flush with the front opening (4) of the casing (11). As shown in FIG. 1, the flat-plate portion (12a) is provided with an inspection window (22). The inspection window (22) is disposed in a right part of the flat-plate portion (12a). The inspection window (22) is a transparent window that allows inspection of the inside of the casing body (12).

[0030]

The recessed portion (12b) is a lower part of the casing (11). The recessed portion (12b) is recessed backward from the lower end of the flat-plate portion (12a). An external storage space (14) is formed in front of the recessed portion (12b). An internal storage space (15) is formed above the recessed portion (12b) and between the flat-plate portion (12a) and the partition plate (13). The lower end of the recessed portion (12b) forms a bottom plate (12c). The bottom plate (12c) extends between the left and right ends of the casing body (12).

25 [0031]

The casing body (12) includes an external casing (16), a heat insulating layer (17), and an internal casing (18), which are stacked in the thickness direction (the front-back direction). The external casing (16) faces the external space (5). The internal casing (18) faces the inside of the container. The heat insulating layer (17) is provided between the external casing (16) and the internal casing (18). The external casing (16) is made of an aluminum material. The internal casing (18) is made of fiber-reinforced plastic (FRP). The heat insulating layer (17) is made of a foamed resin.

[0032]

(2-2) Partition Plate and Air Passage

As shown in FIG. 2, the partition plate (13) is a plate member located behind the recessed portion (12b). The partition plate (13) extends in the top-bottom direction while being spaced at a predetermined distance from the back surface of the recessed portion (12b). An internal passage (19) through which the inside air flows is formed between the casing body (12) and the partition plate (13). An inflow port (20) is formed between the upper end of the partition plate (13) and the upper wall (2a) of the container body (2). The inflow port (20) allows the internal space (3) and the inflow end of the internal passage (19) to communicate with each other. An outflow port (21) is formed between the lower end of the partition plate (13) and the lower wall (2b) of the container body (2). The outflow port (21) allows the internal space (3) and the outflow end of the internal passage (19) to communicate with each other.

[0033]

(2-3) Devices in External Space

The external storage space (14) is provided with the compressor (25), the external heat exchanger (26), and the external fan (27). The compressor (25) is installed on the bottom plate (12c) of the casing (11). The compressor (25) is located in a lower part of the external storage space (14). The compressor (25) is located in a right part of the external storage space (14).

[0034]

The external fan (27) is located in an upper part of the external storage space (14). The external fan (27) is a propeller fan. As shown in FIG. 2, an external passage (28) through which the outside air flows is formed behind the external fan (27).

5 [0035]

In the external storage space (14), the external heat exchanger (26) is located at the level between the external fan (27) and the compressor (25). The external heat exchanger (26) is located in the external passage (28). The external heat exchanger (26) is a fin-and-tube heat exchanger.

10 [0036]

(2-4) Devices in Internal Space

The internal storage space (15) accommodates the internal heat exchanger (29) and the internal fan (30). The internal heat exchanger (29) is supported by the casing (11) so as to extend between the casing body (12) and the partition plate (13). The internal heat exchanger (29) is a
15 fin-and-tube heat exchanger.

[0037]

(2-5) Refrigerant Circuit

As shown in FIG. 3, the cooling unit (10A) includes a refrigerant circuit (R). The refrigerant circuit (R) is filled with a refrigerant. The refrigerant circulates in the refrigerant
20 circuit (R) to perform a vapor compression refrigeration cycle. As the refrigerant in the refrigerant circuit (R), propane or carbon dioxide that is a natural refrigerant is used for example.

[0038]

The refrigerant circuit (R) includes, as main components, the compressor (25), the external heat exchanger (26), an expansion valve (31), and the internal heat exchanger (29).

25 [0039]

The compressor (25) compresses sucked refrigerant. The compressor (25) discharges the compressed refrigerant. The discharge portion of the compressor (25) is connected with a discharge pipe (32). The suction portion of the compressor (25) is connected with a suction pipe (33). The suction pipe (33) is provided with an accumulator (34). The accumulator (34) is a
5 container that stores a liquid refrigerant.

[0040]

The external heat exchanger (26) exchanges heat between the refrigerant flowing therein and the outside air. The gas end of the external heat exchanger (26) communicates with the discharge pipe (32). The liquid end of the external heat exchanger (26) is connected with
10 the liquid end of the internal heat exchanger (29) via a liquid pipe (35). The external heat exchanger (26) functions as a radiator (condenser) through which the refrigerant dissipates heat to the air.

[0041]

The expansion valve (31) is provided in the liquid pipe (35). The expansion valve (31)
15 is an expansion mechanism that decompresses the high-pressure refrigerant to low pressure. The expansion valve (31) is an electronic expansion valve whose opening degree is adjustable. The expansion mechanism may be a capillary tube, or an expander, for example. A receiver (36) is provided in the liquid pipe (35) between the external heat exchanger (26) and the expansion valve (31). The receiver (36) is a container that stores an excessive refrigerant of the
20 refrigerant circuit (R).

[0042]

The internal heat exchanger (29) exchanges heat between the refrigerant flowing therein and the inside air. The gas end of the internal heat exchanger (29) communicates with the suction pipe (33). The internal heat exchanger (29) functions as an evaporator through which
25 the refrigerant absorbs heat from the air.

[0043]

The refrigerant circuit (R) includes a bypass pipe (37). The inflow end of the bypass pipe (37) communicates with the discharge pipe (32), and the outflow end of the bypass pipe (37) communicates with the liquid pipe (35). The bypass pipe (37) sends the refrigerant discharged from the compressor (25) to the internal heat exchanger (29) by allowing the refrigerant to bypass the external heat exchanger (26).

[0044]

The refrigerant circuit (R) is provided with a first valve (38) and a second valve (39). The first valve (38) is provided between the discharge side of the compressor (25) and the gas end of the external heat exchanger (26) and downstream of the connection of the bypass pipe (37). The second valve (39) is provided in the bypass pipe (37). The first valve (38) and the second valve (39) are electromagnetic on-off valves. The first valve (38) and the second valve (39) may be flow rate control valves of which the opening degree is adjustable.

[0045]

(3) Ventilator

A configuration of the ventilator (40) will be described with reference to FIGS. 1, 2, and 4. The ventilator (40) ventilates the internal space (3) of the container body (2). The ventilator (40) of this embodiment has a function of supplying outside air, which is outdoor air, to the internal space (3) and a function of discharging inside air to the external space (5).

[0046]

As shown in FIG. 1, the ventilator (40) is disposed in a left part of the flat-plate portion (12a) of the casing body (12). As shown in FIG. 2, the ventilator (40) is provided in a ventilation mounting opening (6) in the front surface of the casing body (12). The ventilation mounting opening (6) penetrates the casing body (12) from front to back. The ventilation mounting opening (6) extends across the external casing (16), the heat insulating layer (17), and the

internal casing (18).

[0047]

Inside the ventilator (40), an air supply passage (41) and an exhaust passage (42) are formed. The air supply passage (41) and the exhaust passage (42) causes the internal space (3) and the external space (5) to communicate with each other. Specifically, the inflow end of the air supply passage (41) communicates with the external space (5). The outflow end of the air supply passage (41) communicates with a primary side (i.e., an upstream side) of the internal fan (30) in the internal passage (19). The inflow end of the exhaust passage (42) communicates with a secondary side (i.e., a downstream side) of the internal fan (30) in the internal passage (19). The outflow end of the exhaust passage (42) communicates with the external space (5).

[0048]

The ventilator (40) includes a ventilation fan. The ventilation fan is formed by the internal fan (30) described above. The internal fan (30) of this embodiment is shared by both the ventilator (40) and the cooling unit (10A). Once the internal fan (30) is driven, the outside air in the external space (5) is supplied through the air supply passage (41) to the internal space (3). At the same time, the air in the internal space (3) is discharged through the exhaust passage (42) to the external space (5).

[0049]

As shown in FIGS. 2 and 4, an air supply communication port (41a) is open at the end of the air supply passage (41) closer to the external space (5). An exhaust communication port (42a) is open at the end of the exhaust passage (42) closer to the external space (5).

[0050]

As shown in FIG. 2, the ventilator (40) includes a motor (43), a drive shaft (44) that is rotatably driven by the motor (43), and an opening and closing lid (45) connected to the drive shaft (44). The motor (43) and the drive shaft (44) are housed in a casing of the ventilator (40).

The motor (43) is a stepper motor. The drive shaft (44) is directly connected to the motor (43).
The drive shaft (44) may be indirectly connected to the motor (43) via a pinion or a gear.

[0051]

5 The opening and closing lid (45) is provided at the front of the drive shaft (44). The opening and closing lid (45) is rotatable about the axis of the drive shaft (44). The opening and closing lid (45) opens and closes the air supply passage (41) and the exhaust passage (42) in accordance with its rotational angle. The opening and closing lid (45) forms an opening degree adjusting mechanism for adjusting the opening degrees of the air supply passage (41) and the exhaust passage (42).

10 [0052]

As shown in FIG. 4, the opening and closing lid (45) has an air supply opening (46) and an exhaust opening (47). The air supply opening (46) is communicable with the air supply communication port (41a). The exhaust opening (47) is communicable with the exhaust communication port (42a).

15 [0053]

Specifically, being at a first rotation angle (i.e., the closed position) shown in (A) of FIG. 4, the opening and closing lid (45) covers the entire air supply communication port (41a) and the entire exhaust communication port (42a). Accordingly, the air supply passage (41) and the exhaust passage (42) are fully closed.

20 [0054]

When the opening and closing lid (45) is at a second rotational angle (i.e., the fully open position) shown in (C) of FIG. 4, the entire air supply communication port (41a) overlaps the air supply opening (46) and the entire exhaust communication port (42a) overlaps the exhaust opening (47). Accordingly, the air supply passage (41) and the exhaust passage (42) are
25 fully open.

[0055]

When the opening and closing lid (45) is at a third rotational angle (i.e., an intermediate position) shown in (B) of FIG. 4, part of the air supply communication port (41a) overlaps the air supply opening (46) in the axial direction and part of the exhaust communication port (42a) overlaps the exhaust opening (47) in the axial direction. The intermediate position is between the closed position and the fully open position. Accordingly, the air supply passage (41) and the exhaust passage (42) are open at opening degrees smaller than those in the fully-open state.

[0056]

The rotational angle of the opening and closing lid (45) is adjusted between the closed position and the fully open position. This adjustment leads to the adjustment of the opening degrees of the air supply passage (41) and the exhaust passage (42) and further to the adjustment of the amount of ventilation by the ventilator (40).

[0057]

(4) Sensors

The container refrigeration apparatus (10) includes multiple sensors. As shown in FIGS. 2 and 5, the sensors include an internal temperature sensor (51), an external temperature sensor (52), and an oxygen concentration sensor (53).

[0058]

The internal temperature sensor (51) detects the temperature of the air in the container (1) (hereinafter also referred to as an “internal temperature (Ti)”). The internal temperature sensor (51) is disposed upstream of the internal fan (30) with respect to air flow in the internal passage (19). The internal temperature sensor (51) is disposed near the inflow port (20) of the internal passage (19).

[0059]

The external temperature sensor (52) detects the temperature of the outside air outside

the container (1) (hereinafter also referred to as an “external temperature (To)”). The external temperature sensor (52) is disposed upstream of the external heat exchanger (26) with respect to the air flow in the external passage (28). The external temperature sensor (52) is disposed near the inflow port of the external passage (28).

5 [0060]

The oxygen concentration sensor (53) is an air quality sensor that detects the concentration of a component in the inside air. The oxygen concentration sensor (53) detects the oxygen concentration in the inside air. The oxygen concentration sensor (53) is disposed upstream of the internal fan (30) with respect to the air flow in the internal passage (19). The
10 oxygen concentration sensor (53) is disposed near the inflow port (20) of the internal passage (19).

[0061]

As shown in FIGS. 3 and 5, the sensors include a high-pressure sensor (54), a low-pressure sensor (55), and a suction temperature sensor (56). The high-pressure sensor (54) is
15 provided in a high-pressure line of the refrigerant circuit (R), for example, in the discharge pipe (32) of the compressor (25). The high-pressure sensor (54) detects the pressure of the high-pressure refrigerant in the refrigerant circuit (R). The low-pressure sensor (55) is provided in a low-pressure line of the refrigerant circuit (R), for example, in the suction pipe (33) of the compressor (25). The low-pressure sensor (55) detects the pressure of the low-pressure
20 refrigerant in the refrigerant circuit (R). The suction temperature sensor (56) detects the temperature of the refrigerant sucked into the compressor (25).

[0062]

(5) Control Unit and Operation Unit

As shown in FIG. 5, the container refrigeration apparatus (10) includes a control unit
25 (100). The control unit (100) controls the cooling unit (10A) and the ventilator (40). The control

unit (100) includes a microprocessor, an electric circuit, and an electronic circuit. The microprocessor includes a central processing unit (CPU), a memory, a communication interface, an analog input/output, and a contact input/output interface. The memory stores various programs executed by the CPU and the data employed by the programs.

5 [0063]

The control unit (100) controls the devices of the cooling unit (10A). Specifically, the control unit (100) controls the number of rotations of the compressor (25), the number of rotations of the internal fan (30), the number of rotations of the external fan (27), the opening degree of the expansion valve (31), and other factors. The control unit (100) controls the motor
10 (43) of the ventilator (40). The control unit (100) adjusts the opening degrees of the air supply passage (41) and the exhaust passage (42) of the ventilator (40), and further adjusts the amount of ventilation by the ventilator (40).

[0064]

As shown in FIG. 5, the container refrigeration apparatus (10) includes an operation
15 unit (110). The operation unit (110) includes, for example, a touch panel, a remote controller, a switch, or any other suitable element provided in the container refrigeration apparatus (10). The operation unit (110) may be a communication terminal connected to the container refrigeration apparatus (10) via a network. The user can switch the operating modes of the container refrigeration apparatus (10) and change the set values in the operating modes by operating the
20 operation unit (110). The set values include a target temperature of the internal space (3).

[0065]

(6) Operation

The container refrigeration apparatus (10) performs a cooling operation and a defrosting operation. The cooling operation is an operating mode executed by a user, for
25 example, operating the operation unit (110).

[0066]

When the cooling operation is performed, the refrigeration cycle is performed in which the refrigerant compressed by the compressor (25) is condensed in the external heat exchanger (26), then decompressed by the expansion valve (31), and then evaporates in the internal heat exchanger (29). The air having flowed out from the internal space (3) to the internal passage (19) is cooled by the internal heat exchanger (29) that functions as an evaporator. The cooled air is sent to the internal space (3).

[0067]

In principle, the control unit (100) controls the number of rotations of the compressor (25), based on the difference between the temperature of the inside air in the internal space (3) and the target temperature in the cooling operation. In principle, the control unit (100) controls the opening degree of the expansion valve (31), based on the degree of sucked superheat of the refrigerant circuit (R) in the cooling operation. The suction superheat degree is obtained from a difference between a saturation temperature associated with the low pressure detected by the low-pressure sensor (55) and the temperature of the refrigerant detected by the suction temperature sensor (56).

[0068]

When the defrosting operation is performed, the refrigerant compressed in the compressor (25) flows through the bypass pipe (37) and then flows through the internal heat exchanger (29). The frost on the surface of the internal heat exchanger (29) is melted by the heat of the refrigerant flowing through the inside of the internal heat exchanger (29).

[0069]

(7) Control in Accordance with Ventilating Operation in Cooling Operation

(7-1) Outline

In the cooling operation described above, the inside of the container (1) is cooled by

the internal heat exchanger (29) serving as an evaporator. In the cooling operation, once the ventilator (40) performs a ventilating operation for supplying the outside air into the container, the temperature of the inside air changes under influence of heat input from the outside air. As a result, there arises a problem that the temperature of the object cannot be maintained at a desired temperature. To address the problem, the container refrigeration apparatus (10) of this embodiment adjusts the cooling capability of the cooling unit (10A) based on the ventilation cooling load in accordance with the ventilating operation. Specifically, the control unit (100) adjusts the cooling capability based on the internal cooling load and the ventilation cooling load. The internal cooling load here is the current internal cooling load. The ventilation cooling load changes in accordance with the operation of the ventilator (40). The ventilation cooling load increases with an increase in the amount of ventilation by the ventilator (40) and decreases with a decrease in the amount of ventilation by the ventilator (40).

[0070]

(7-2) Switching between Modes

Switching between the modes of the cooling operation will be described. The user can select a usual mode, a ventilation load reduction mode, which is a first mode, and a cooling priority mode, which is a second mode, by operating the operation unit (110). The usual mode is a mode in which the ventilation of the inside of the container is prioritized over cooling. The ventilation load reduction mode is a mode in which a change in the ventilation cooling load is reduced. The cooling priority mode is a mode in which the cooling of the inside of the container is prioritized over ventilation.

[0071]

As shown in FIG. 6, once a command to start the cooling operation is input to the control unit (100) in step S11, the cooling operation starts in step S12. In step S13, if the ventilation load reduction mode is selected through the operation of the operation unit (110),

the operation unit (110) outputs a first command for executing the ventilation load reduction mode to the control unit (100). The control unit (100), to which the first command is input, executes the ventilation load reduction mode in step S17.

[0072]

5 In step S14, if the cooling priority mode is selected through the operation of the operation unit (110), the operation unit (110) outputs a second command to the control unit (100). The control unit (100), to which the second command is input, executes the cooling priority mode in step S16. If the ventilation load reduction mode is not selected in step S13 and the cooling priority mode is not selected in step S14, the operation unit (110) outputs a third
10 command to the control unit (100) to execute the usual mode. The control unit (100), to which the third command is input, executes the usual mode in step S15.

[0073]

Once a command to end the cooling operation is input to the control unit (100) in step S18, the cooling operation ends in step S19.

15 [0074]

(7-3) Usual Mode

The usual mode will be described with reference to FIG. 7.

[0075]

Once the usual mode starts, in step S21, the control unit (100) determines a target
20 amount (V_t) of ventilation (i.e., a first ventilation amount) by the ventilator (40), based on the current oxygen concentration (C_i) and a target oxygen concentration (C_t) in the inside air. The current oxygen concentration (C_i) of the inside air is detected by the oxygen concentration sensor (53). The target oxygen concentration (C_t) is set by the user operating the operation unit (110) in accordance with the type of the object stored in the container (1) or the storage period,
25 for example. If the current oxygen concentration (C_o) is lower than the target oxygen

concentration (Ct), the target amount (Vt) of ventilation by the ventilator (40) increases. If the current oxygen concentration (Ci) is higher than the target oxygen concentration (Ct), the target amount (Vt) of ventilation becomes zero.

[0076]

- 5 The control unit (100) determines the target amount (Vt) of ventilation using the following Equation (1).

[0077]

$$V_t = (C_t - C_i) \times A / (t_1 \times C_o) \dots (1)$$

- Here, Ct represents the target oxygen concentration [%], Ci represents the current
10 oxygen concentration [%] of the inside air, A represents the volume of the internal space (3) in the container (1), t1 represents the execution time [h] of the ventilating operation for causing the oxygen concentration to converge to the target oxygen concentration, and Co represents the oxygen concentration [%] of the outside air. The volume (A) of the internal space (3) is set by the user, for example, operating the operation unit (110). The oxygen concentration (Co) of the
15 outside air is set to 21%, for example.

[0078]

- Next, in step S22, the control unit (100) predicts a ventilation cooling load (L1) according to the target amount (Vt) of ventilation obtained in step S21. The ventilation cooling load (L1) of this embodiment corresponds to a sensible heat load applied to the internal space
20 (3) through the ventilating operation by the ventilator (40). The control unit (100) calculates the ventilation cooling load (L1) using the following Equation (2).

[0079]

$$L_1 = \alpha \times V_t \times (T_o - T_i) \dots (2)$$

- Here, L1 represents the ventilation cooling load [W] and corresponds to a sensible heat
25 load (Ls) associated with the ventilation in this example. Vt represents the target amount [m³/h]

of ventilation by the ventilator (40), and α represents a coefficient (e.g., 0.33) in view of the specific heat and density of the air. T_o represents the temperature of the outside air (hereinafter also referred to as the “external temperature”) [°C], and T_i represents the temperature of the inside air (hereinafter also referred to as the “internal temperature”) [°C]. The external temperature (T_o) is detected by the external temperature sensor (52). The internal temperature (T_i) is detected by the internal temperature sensor (51).

[0080]

In step S23, the control unit (100) estimates an internal cooling load (L_2). The internal cooling load (L_2) [W] corresponds to the current cooling capability of the cooling unit (10A).

The internal cooling load (L_2) is determined by the current number of rotations of the compressor (25), the high pressure of the refrigerant circuit (R), and the low pressure of the refrigerant circuit (R). The current number of rotations of the compressor (25) is determined by the temperature difference between the internal temperature (T_i) and the target temperature (T_s) of the internal space (3). With an increase in the temperature difference, the target evaporation temperature of the internal heat exchanger (29) decreases and eventually the number of rotations of the compressor (25) increases. With a decrease in the temperature difference, the target evaporation temperature of the internal heat exchanger (29) increases and eventually the number of rotations of the compressor (25) decreases. The high pressure is detected by the high-pressure sensor (54). The low pressure is detected by the low-pressure sensor (55).

[0081]

The control unit (100) estimates the internal cooling load (L_2) from the capacity characteristics of the compressor (25) based on the current number of rotations of the compressor (25), the high pressure, and the low pressure. The control unit (100) may estimate the internal cooling load (L_2) using a function or a table.

[0082]

The control unit (100) may execute the process in step S23 before the process in step S22.

[0083]

In step S24, the control unit (100) determines a target cooling capability (i.e., a first cooling capability) of the cooling unit (10A), based on the ventilation cooling load (L1) determined in step S22 and the internal cooling load (L2) estimated in step S23. The process in step S24 corresponds to the first control. Specifically, the control unit (100) determines the target number (Nt) of rotations [rps] of the compressor (25) using the following Equation (3).

[0084]

$$N_t = N_c \times (L_1 + L_2) / L_2 \dots (3)$$

Here, Nc represents the current number of rotations [rps] of the compressor (25).

[0085]

According to Equation (3), with an increase in the target amount (Vt) of ventilation by the ventilator (40) and further in the ventilation cooling load (L1), the target number (Nt) of rotations of the compressor (25) increases. With a decrease in the target amount (Vt) of ventilation by the ventilator (40) and further in the ventilation cooling load (L1), the target number (Nt) of rotations of the compressor (25) decreases.

[0086]

Next, in step S25, the ventilator (40) is controlled so that the current amount of ventilation by the ventilator (40) approaches the target amount (Vt) of ventilation. The process in step S25 corresponds to the second control. With an increase in the target amount (Vt) of ventilation, the opening degree of the ventilation opening (VO) of the ventilator (40) increases and the amount of ventilation increases. With a decrease in the target amount (Vt) of ventilation, the opening degree of the ventilation opening (VO) of the ventilator (40) decreases and the amount of ventilation decreases. When the target amount (Vt) of ventilation is zero, the

ventilation opening (VO) of the ventilator (40) is fully closed, and the amount of ventilation becomes zero.

[0087]

In step S26, the control unit (100) controls the cooling unit (10A) so that the cooling capability of the cooling unit (10A) approaches first cooling capability. The process in step S26 corresponds to the third control. The first cooling capability corresponds to the sum of the internal cooling load and the ventilation cooling load. Specifically, the control unit (100) controls the compressor (25) so that the number of rotations of the compressor (25) approaches the target number (Nt) of rotations determined in step S25.

10 [0088]

In this manner, the control unit (100) of this embodiment determines the number of rotations of the compressor (25) and thus the cooling capability of the cooling unit (10A), based on the ventilation cooling load (L1) in addition to the current internal cooling load (L2). In other words, the control unit (100) performs feed-forward control with the ventilation cooling load (L1) corresponding to the target amount (Vt) of ventilation by the ventilator (40) regarded as a control index. Accordingly, at the timing at which the amount of ventilation by the ventilator (40) reaches the target amount (Vt) of ventilation, the cooling capability of the cooling unit (10A) approaches the cooling capability capable of processing the ventilation cooling load (L1). As a result, a large change in the temperature of the air in the internal space (3) in accordance with the ventilating operation by the ventilator (40) can be reduced. As a result, impairment of the control of the temperature of the object can be reduced.

20 [0089]

The control unit (100) may start the second control in step S25 and the third control in step S26 at the same time, or may start the third control in step S26 before the second control in step S25.

25

[0090]

(7-4) Ventilation Load Reduction Mode

As described above, in the usual mode, the cooling capability of the cooling unit (10A) is determined based on the ventilation cooling load. On the other hand, in the usual mode, with a large change in the amount of ventilation by the ventilator (40), the cooling capability of the cooling unit (10A) may not be able to sufficiently follow this change. Specifically, in the usual mode, if there is a large difference between the target number of rotations of the compressor (25) obtained by Equation (3) and the current number of rotations of the compressor (25), the number of rotations of the compressor (25) changes at a higher rate in the third control in step S26. Here, the rate of change corresponds to the amount of change of the compressor in a predetermined period. If the rate of change in the number of rotations of the compressor (25) exceeds the predetermined limit value, the compressor (25) may not be able to be controlled sufficiently or the compressor (25) or other devices may fail. In the ventilation load reduction mode, such a problem is solved by reducing the variation in the ventilation cooling load.

[0091]

The ventilation load reduction mode will be described in detail with reference to FIG. 8.

[0092]

Once the ventilatory load reduction mode starts, the processes in steps S31 to S34 are executed. Since these processes are the same as the processes in steps S21 to S24 in the usual mode, detailed description thereof will be omitted.

[0093]

Next, in step S35, the control unit (100) determines whether the absolute value of the difference between the number of rotations of the compressor (25) and the target number of rotations of the compressor (25) are larger than the first value. This absolute value serves as an

index of the rate of change in the cooling capability of the cooling unit (10A). The first value is a limit value of the rate of change in the number of rotations of the compressor (25).

[0094]

If the absolute value of the difference between the target number (Nt) of rotations and the current number (Nc) of rotations is smaller than the first value, the process proceeds to the normal operation in steps S36 to S37. In this case, the control unit (100) does not limit the amount of ventilation by the ventilator (40). In step S36, the control unit (100) controls the ventilator (40) so that the amount of ventilation approaches the target amount (Vt) of ventilation. In step S37, the control unit (100) controls the cooling unit (10A) so that the cooling capability of the cooling unit (10A) approaches the target cooling capability, that is, the number of rotations of the compressor (25) approaches the target number (Nt) of rotations. In the normal operation, the rate of change in the number of rotations of the compressor (25) is smaller than the first value, which does not cause the problem described above.

[0095]

When the absolute value of the difference between the target number (Nt) of rotations and the current number (Nc) of rotations is larger than the first value, the process proceeds to the first limiting operation in steps S41 to S45.

[0096]

In step S41, the control unit (100) determines the limit amount (Vl) of ventilation. The limit amount (Vl) of ventilation is for keeping the rate of change (i.e., the absolute value described above) in the number (Nc) of rotations of the compressor (25) not to exceed the first value. The control unit (100) determines the limit amount (Vl) of ventilation in the following procedure in step S41.

[0097]

In step S41, the control unit (100) first calculates the limit amount (ΔW) of change in

the cooling capability using Equation (4).

[0098]

$$\text{Limit Amount } (\Delta W) \text{ of Change in Cooling Capability} = R2/Rc \times L2 - L2 \dots (4)$$

The limit amount (ΔW) of change in the cooling capability is an amount of change in the cooling capability obtained when the number of rotations of the compressor (25) is limited within the limit range ($\Delta R1$) [rps]. $R2$ represents the limit number of rotations [rps] after the current number of rotations of the compressor (25) is changed within the limit range ($\Delta R1$) in an operating time ($t2$). The limit range ($\Delta R1$) is the range of variation [rps] in the number of rotations of the compressor (25) that can be controlled in the operating time ($t2$). $\Delta R1$ is set to 5 [rps], for example, and the operating time ($t2$) is set to 20 seconds, for example. If the current amount of ventilation is smaller than the target amount (Vt) of ventilation, the amount of ventilation by the ventilator (40) increases. There is thus a need to increase the number of rotations of the compressor (25). Thus, if the current amount of ventilation is smaller than the target amount (Vt) of ventilation, the limit number ($R2$) of rotations is the value obtained by adding $\Delta R1$ to the current number (Nc) of rotations of the compressor (25). If the current amount of ventilation is larger than the target amount (Vt) of ventilation, the amount of ventilation by the ventilator (40) decreases. There is thus a need to decrease the number of rotations of the compressor (25). Thus, if the current amount of ventilation is larger than the target amount (Vt) of ventilation, the limit number ($R2$) of rotations is the value obtained by subtracting the limit range ($\Delta R1$) from the current number (Nc) of rotations of the compressor (25).

[0099]

Next, in step S41, the control unit (100) determines the limit amount (Vl) of ventilation using Equation (5).

25 [0100]

$$\text{Limit Amount (Vl) of Ventilation} = V_c + \Delta W/L1' \dots (5)$$

Here, V_c represents the current amount [m^3/h] of ventilation by the ventilator (40), and ΔW represents the limit amount [W] of change in cooling capability obtained by Equation (4).

$L1'$ represents the ventilation cooling load per ventilation volume 1 m^3 , and is obtained by dividing the ventilation cooling load ($L1$) by the target amount (V_t) of ventilation.

[0101]

In step S42, the control unit (100) controls the ventilator (40) so that the amount of ventilation by the ventilator (40) approaches the limit amount (V_l) of ventilation.

[0102]

In step S43, the control unit (100) controls the cooling unit (10A) so that the cooling capability of the cooling unit (10A) approaches the limit cooling capability. The limit cooling capability is the target value of the cooling capability for limiting the variation range of the cooling capability of the cooling unit (10A) to a first value or less. Specifically, in step S43, the control unit (100) controls the cooling unit (10A) so that the number of rotations of the compressor (25) approaches the limit number (R_2) of rotations described above.

[0103]

Next, if the amount of ventilation by the ventilator (40) has not reached the target amount (V_t) of ventilation (NO in step S44) and the operating time (t_2) has elapsed (YES in step S45), the control unit (100) repeats the process in steps S41 to 43. In step S44, once the amount of ventilation by the ventilator (40) reaches the target amount (V_t) of ventilation, the first limiting operation ends.

[0104]

In this manner, in the first limiting operation, the control unit (100) performs feed-forward control with the ventilation cooling load according to the limit amount (V_l) of ventilation of the ventilator (40) regarded as a control index. Accordingly, at the timing at which

the amount of ventilation by the ventilator (40) reaches the limit amount (V1) of ventilation, the cooling capability of the cooling unit (10A) approaches the cooling capability capable of processing the ventilation cooling load (L1). As a result, a large change in the temperature of the air in the internal space (3) in accordance with the ventilating operation by the ventilator (40) can be reduced. As a result, the temperature around the object can be managed sufficiently.

[0105]

In addition, in the first limiting operation, the rate of change in the cooling capability of the cooling unit (10A) is limited to the first value or less. Specifically, in the operating time (t2), the range of variation in the number of rotations of the compressor (25) is limited to the limit value ($\Delta R1$). This can reduce the problem that the compressor (25) is not sufficiently controlled or the compressor (25) or other devices malfunction due to an excessive increase in the range of variation in the number of rotations of the compressor (25).

[0106]

(7-5) Cooling Priority Mode

As described above, in the usual mode, the cooling capability of the cooling unit (10A) is determined based on the ventilation cooling load. On the other hand, in the usual mode, with a large increase in the amount of ventilation by the ventilator (40), the cooling capability of the cooling unit (10A) may become excessively large and the inside of the container may not be able to be sufficiently cooled. In this case, the temperature of the inside air rises, which may impair the management of the temperature of the object. In the cooling priority mode, if the cooling capability of the cooling unit (10A) is higher than a predetermined value, the control unit (100) limits the amount of ventilation by the ventilator (40).

[0107]

The cooling priority mode will be described with reference to FIG. 9.

[0108]

In the cooling priority mode, basically, the same process as in the normal operating mode is performed. In steps S51 to S56, the control unit (100) performs the same process as in steps S21 to S26.

[0109]

5 Here, if the index indicating the cooling capability of the cooling unit (10A) is larger than the predetermined value in step S57, the control unit (100) limits the amount of ventilation by the ventilator (40) in step S58. Specifically, if the number of rotations of the compressor (25) is higher than the second value in step S57, the control unit (100) controls the ventilator (40) in step S58 so that the amount of ventilation by the ventilator (40) approaches a predetermined
10 value that is smaller than the target amount (V_t) of ventilation. The control unit (100) may set the amount of ventilation by the ventilator (40) to zero in step S58. As a result, in the internal space (3), the input heat of the outdoor air in accordance with the ventilating operation can be reduced, which can reduce the temperature rise in the internal space (3). After that, with a decrease in the difference between the internal temperature (T_i) and the target temperature (T_s),
15 the number of rotations of the compressor (25) decreases.

[0110]

 Here, if the index indicating the cooling capability of the cooling unit (10A) is smaller than the predetermined value in step S59, the control unit (100) releases the limit of the amount of ventilation by the ventilator (40) in step S60. Specifically, if the number of rotations of the
20 compressor (25) is smaller than the third value, the control unit (100) releases the limit of the amount of ventilation by the ventilator (40). After that, the process in steps S51 to S56 is thus executed again. Specifically, the control unit (100) controls the ventilator (40) so that the amount of ventilation by the ventilator (40) approaches a target amount of ventilation.

[0111]

25 (8) Advantages of Embodiment

In this embodiment, the control unit (100) adjusts the cooling capability of the cooling unit (10A), based on the ventilation cooling load that is the cooling load in accordance with a ventilating operation of the ventilator (40).

[0112]

5 This can reduce a change in the temperature of the inside air due to an increase or a decrease in the amount of ventilation by the ventilating operation of the ventilator (40). As a result, the temperature around the internal space (3) is easily kept at the target temperature, and the object can thus be sufficiently managed. This can reduce the frequency of starting and stopping the compressor (25) due to the temperature change of the inside air, and the life of the
10 compressor (25) can thus be extended.

[0113]

In this embodiment, the control unit (100) controls the ventilator (40) to bring the amount of ventilation by the ventilator (40) closer to a first ventilation amount (i.e., the target amount of ventilation); and adjusts the cooling capability of the cooling unit (10A), based on
15 the internal cooling load that is the cooling load inside the container and the ventilation cooling load according to the first ventilation amount.

[0114]

When the amount of ventilation converges to the target amount of ventilation, the cooling capability of the cooling unit (10A) reaches the cooling capability capable of processing
20 the ventilation cooling load according to the target amount of ventilation. As a result, a change in the temperature of the inside air in accordance with the ventilating operation can be reduced.

[0115]

In this embodiment, the control unit (100) executes: first control (e.g., step S24) of determining a first cooling capability (i.e., the target cooling capability) of the cooling unit
25 (10A), based on the internal cooling load and the ventilation cooling load according to the first

ventilation amount (i.e., the target amount of ventilation); second control (e.g., step S25) of causing the amount of ventilation by the ventilator (40) to approach the first ventilation amount (i.e., the target amount of ventilation) after the first control; and third control of causing the cooling capability of the cooling unit (10A) to approach the first cooling capability (i.e., the target cooling capability) after the first control.

[0116]

This allows the timing at which the cooling capability of the cooling unit (10A) reaches the target cooling capability and the time at which the amount of ventilation by the ventilator (40) reaches the target amount of ventilation are closer to each other. As a result, a change in the temperature of the inside air in accordance with the ventilating operation can be reduced.

[0117]

In this embodiment, in the ventilation load reduction mode, which is the first mode, the control unit (100) performs a first limiting operation of limiting a rate of change in the amount of ventilation by the ventilator (40) so that an index indicating a rate of change in the cooling capability of the cooling unit (10A) in accordance with the ventilating operation of the ventilator (40) is smaller than or equal to a predetermined value. Specifically, in the first limiting operation, the rate of change over time in the amount of ventilation by the ventilator (40) is limited so that the rate of change in the number of rotations of the compressor (25) is lower than or equal to a predetermined value.

[0118]

This can reduce the excess of the variation range of the number of rotations of the compressor (25) over the limit value, insufficient control of the compressor (25) and malfunction of the compressor (25) and other devices. As a result, the reliability of the container refrigeration apparatus (10) can be ensured.

[0119]

In this embodiment, the control unit (100) executes the first limiting operation when the first mode is selected through the operation of the operation unit (110).

[0120]

Whether to prioritize the ventilation by the ventilator (40) or reduction in a change in the cooling load of the ventilator (40) can be selected through the operation of the operation unit (110) by the user.

[0121]

In this embodiment, the control unit (100) performs a second limiting operation of limiting the amount of ventilation by the ventilator (40) when the index indicating the cooling capability of the cooling unit (10A) is greater than a predetermined value. Specifically, if the number of rotations of the compressor (25) is larger than the predetermined value, the control unit (100) executes the second limiting operation of limiting the amount of ventilation by the ventilator (40).

[0122]

Accordingly, the ventilation cooling load can be reduced under the condition where the inside of the compartment cannot be sufficiently cooled because the number of rotations of the compressor (25) excessively increases in accordance with the ventilating operation by the ventilator (40). As a result, an increase in the temperature of the inside air in accordance with the ventilating operation can be reduced.

[0123]

(9) Variations

The above embodiments may be modified as follows. In the following description, differences from the embodiments will be described in principle.

[0124]

(9-1) First Variation

A control unit (100) of a first variation determines not only the target number (Nt) of rotations of the compressor (25) but also the target opening degree (Dt) of the expansion valve (31) in the first control of step S26 in the usual mode. Specifically, the control unit (100) determines the target opening degree (Dt) of the expansion valve (31) using the following
5 Equation (6).

[0125]

$$Dt = Dc \times Nt/Nc \dots (6)$$

Here, Dt represents the target opening degree [pls] of the expansion valve (31), and Nt represents the target number of rotations [rps] of the compressor (25) determined in the first
10 control in step S24 as described above, and is the current number of rotations [rps] of the compressor (25).

[0126]

In the third control in step S26, the control unit (100) of the first variation controls the expansion valve (31) so that the number of rotations (Nc) of the compressor (25) approaches
15 the target number (Nt) of rotations and the opening degrees of the expansion valve (31) approach the target opening degree (Dt).

[0127]

Accordingly, the opening degree of the expansion valve (31) is adjusted to follow the control of the number of rotations of the compressor (25), which can reduce a change in the
20 evaporation temperature of the internal heat exchanger (29) in accordance with the ventilating operation. As a result, a change in the temperature of the inside air in accordance with the ventilating operation can be reduced.

[0128]

The control of the expansion valve of the first variation may be applied to the
25 ventilation load reduction mode and the cooling priority mode.

[0129]

(9-2) Second Variation

When estimating the ventilation cooling load in step S22, the control unit (100) of a second variation sets the sum of the sensible heat load (Ls) and the sensible heat load (Ls) as the ventilation cooling load (L1). Here, the control unit (100) obtains the latent heat load (LL) using the following Equation (7).

[0130]

$$LL = \beta \times Vt \times (ho - hi) \dots (7)$$

Here, LL represents a latent heat load [W] applied from the outside air to the internal space (3) through the ventilating operation. Vt represents the target amount [m³/h] of ventilation by the ventilator (40), and β represents a coefficient (e.g., 830) in view of the latent heat of vaporization of water and the density of air. ho represents the absolute humidity [kg/kg (DA)] of the outside air, and hi represents the absolute humidity [kg/kg (DA)] of the inside air. The absolute humidity (Ro) of the outside air is detected by an outside humidity sensor disposed outside. The absolute humidity (Ri) of the inside air is detected by an inside humidity sensor disposed inside.

[0131]

By obtaining the ventilation cooling load in this manner, the target cooling capability according to the latent heat load can be determined. As a result, a change in the temperature of the inside air under the influence of the latent heat load in accordance with the ventilating operation can be reduced.

[0132]

The control of the expansion valve of the second variation may be applied to the ventilation load reduction mode and the cooling priority mode.

[0133]

(10) Other Embodiments

The above-described embodiments and variations may have the following configurations.

[0134]

5 The container (1) is not necessarily for marine transportation, but may be for land transportation carried by a vehicle, such as a trailer, or by rail.

[0135]

 The ventilator (40) may have only the function of supplying the outside air in the external space (5) to the internal space (3) and does not necessarily have the function of
10 exhausting air. In other words, the ventilator (40) may have only the air supply passage (41) and the air may be naturally discharged from the exhaust port provided in the container body (2).

[0136]

 The ventilation fan of the ventilator (40) may be a fan dedicated to ventilation, which
15 is different from the internal fan.

[0137]

 The opening degree adjusting mechanism for adjusting the opening degrees of the air supply passage (41) and the exhaust passage (42) is not necessarily the opening and closing lid (45). The opening degree adjusting mechanism may be a damper or a valve mechanism
20 provided in the air supply passage (41) or the exhaust passage (42).

[0138]

 The control unit (100) may determine the target amount of ventilation by the ventilator (40), based on the carbon dioxide concentration detected by a carbon dioxide concentration sensor and a target carbon dioxide concentration.

25 [0139]

The container refrigeration apparatus (10) may include an air composition adjusting device that adjusts the composition of oxygen, carbon dioxide, or nitrogen, for example, in the air in the internal space (3). The air composition adjusting device adjusts the air in the internal space (3) using a pressure swing adsorption (PSA) or a gas separation membrane, for example.

5 [0140]

The control unit (100) may adjust the cooling capability of the cooling unit (10A), based not on the ventilation cooling load according to the target amount of ventilation by the ventilator (40), but on the ventilation cooling load according to the current amount of ventilation by the ventilator (40).

10 [0141]

The control parameters for adjusting the cooling capability of the cooling unit (10A) include not the number of rotations of the compressor (25) but the operation frequency of the compressor (25), the evaporation temperature of the internal heat exchanger (29), the volume of air in the internal fan (30), the volume of air in the external fan (27), and other elements.

15 [0142]

The index indicating the rate of change in the cooling capability for determining the first limiting operation includes not only the number of rotations of the compressor (25) but also the operation frequency of the compressor (25), the evaporation temperature of the internal heat exchanger (29), the evaporation pressure of the internal heat exchanger (29), and other parameters.

20 [0143]

In the second limiting operation, the control unit (100) may control the ventilator (40) based on not only the number of rotations of the compressor (25) but also the operation frequency of the compressor (25), the evaporation temperature of the internal heat exchanger (29), and the evaporation pressure of the internal heat exchanger (29).

25

[0144]

The index indicating the cooling capability of the cooling unit (10A) for determining the second limiting operation include not only the number of rotations of the compressor (25) but also the operation frequency of the compressor (25), the evaporation temperature of the internal heat exchanger (29), the evaporation pressure of the internal heat exchanger (29), and other parameters.

[0145]

(11) Reference Embodiment

In a reference embodiment, the control unit (100) adjusts the cooling capability of the cooling unit (10A), based not on the ventilation cooling load but on the internal cooling load. The internal cooling load includes the internal temperature and the target temperature. The control unit (100) controls the ventilator (40), based on the cooling capability of the cooling unit (10A) in an operation in which the ventilator (40) performs the ventilating operation and the cooling unit (10A) performs the cooling operation of cooling the inside at the same time. Specifically, the control unit (100) limits the amount of ventilation by the ventilator (40), if the index indicating the cooling capability of the cooling unit (10A) is larger than a predetermined value. This can reduce the cooling load caused by introduced outside air, if the cooling capability of the cooling unit (10A) becomes excessive in accordance with the ventilating operation. As a result, a change in the temperature of the inside air can be reduced.

[0146]

While the embodiments and variations thereof have been described above, it will be understood that various changes in form and details may be made without departing from the spirit and scope of the claims. The embodiments, the variations, and the other embodiments may be combined and replaced with each other without deteriorating intended functions of the present disclosure.

[0147]

The expressions of “first,” “second,” and “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.

5

INDUSTRIAL APPLICABILITY

[0148]

As described above, the present disclosure is useful for a container refrigeration apparatus.

10

DESCRIPTION OF REFERENCE CHARACTERS

[0149]

1	Container
10	Container Refrigeration Apparatus
15	10A Cooling Unit
25	Compressor
26	External Heat Exchanger (Radiator)
29	Internal Heat Exchanger (Evaporator)
31	Expansion Valve (Expansion Mechanism)
20	40 Ventilator
100	Control Unit
110	Operation Unit
L1	Ventilation Cooling Load
L2	Internal Cooling Load

CLAIMS

[Claim 1] A container refrigeration apparatus, comprising:

5 a cooling unit (10A) including a compressor (25), a radiator (26), an expansion mechanism (31), and an evaporator (29) and being configured to perform, by the evaporator (29), a cooling operation of cooling an inside of a container (1);

a ventilator (40) configured to supply outside air into the container (1); and

a control unit (100) configured to control the cooling unit (10A) and the ventilator (40),

wherein

10 the control unit (100) adjusts a cooling capability of the cooling unit (10A), based on a ventilation cooling load that is a cooling load in accordance with a ventilating operation of the ventilator (40).

[Claim 2] The container refrigeration apparatus of claim 1, wherein

15 the control unit (100)

controls the ventilator (40) so that an amount of ventilation by the ventilator (40) approaches a first ventilation amount, and

adjusts the cooling capability of the cooling unit (10A), based on an internal cooling load that is a cooling load inside the container and the ventilation cooling load
20 according to the first ventilation amount.

[Claim 3] The container refrigeration apparatus of claim 2, wherein

the control unit (100) executes

first control of determining a first cooling capability of the cooling unit (10A),
25 based on the internal cooling load and the ventilation cooling load according to the first

ventilation amount,

second control of causing the amount of ventilation by the ventilator (40) to approach the first ventilation amount after the first control; and

third control of causing the cooling capability of the cooling unit (10A) to approach the first cooling capability after the first control.

[Claim 4] The container refrigeration apparatus of any one of claims 1 to 3, wherein

the control unit (100) performs a first limiting operation of limiting a rate of change in an amount of ventilation by the ventilator (40) so that an index indicating a rate of change in the cooling capability of the cooling unit (10A) in accordance with the ventilating operation of the ventilator (40) is lower than or equal to a predetermined value.

[Claim 5] The container refrigeration apparatus of claim 4, wherein the control unit (100) executes the first limiting operation when a first mode is selected through an operation of an operation unit (110).

[Claim 6] The container refrigeration apparatus of any one of claims 1 to 5, wherein the control unit (100) controls the ventilator (40), based on the cooling capability of the cooling unit (10A).

[Claim 7] The container refrigeration apparatus of claim 6, wherein the control unit (100) performs a second limiting operation of limiting an amount of ventilation by the ventilator (40) when an index indicating the cooling capability of the cooling

unit (10A) is greater than a predetermined value.

[Claim 8] The container refrigeration apparatus of claim 7, wherein

the control unit (100) performs the second limiting operation when a second mode is

5 selected through an operation of an operation unit (110).