

DESCRIPTION

Title of Invention

REFRIGERATOR

Technical Field

5 [0001]

The present invention relates to a refrigerator, and particularly, to a refrigerator including a freezing chamber and a storage chamber different from the freezing chamber (a storage chamber such as a refrigerating chamber having a temperature zone different from that of the freezing chamber).

10 Background Art

[0002]

Hitherto, refrigerators including a freezing chamber and a storage chamber different from the freezing chamber (a storage chamber such as a refrigerating chamber having a temperature zone different from that of the freezing chamber) have been known. In such conventional refrigerators, an evaporator (cooler) and an internal fan of a refrigeration cycle are installed at an air passage communicating to each storage chamber, and each storage chamber is cooled with one evaporator and one internal fan. Specifically, when the temperature of a freezing chamber gets higher than a setting temperature, a compressor and an internal fan of a refrigeration cycle are driven. Furthermore, when the temperature of a storage chamber different from the freezing chamber gets higher than the setting temperature, control is performed such that a damper provided at a cold air supply port of the storage chamber is opened to reduce the temperature of the storage chamber to a temperature lower than or equal to the setting temperature and the damper is then closed. Thus, a conventional refrigerator including a freezing chamber and a storage chamber different from the freezing chamber has a problem that, even with a low internal load, when the

15

20

25

damper is opened, the amount of cold air supplied to the freezing chamber is reduced, variations in the temperature of the freezing chamber are thus increased, and therefore, reducing the temperature of the freezing chamber increases the driving time of a compressor and thus increases power consumption.

[0003]

A conventional refrigerator provided with a freezing chamber and a storage chamber different from the freezing chamber, to achieve suppression of variations in the temperature of the freezing chamber and other chambers, "including a main body, a refrigerating chamber formed at the main body and refrigerating foods, a cooler arranged within a cooling chamber formed on a rear side of the main body, the cooler cooling air flowing in the cooling chamber and generating cold air, a duct unit to send cold air from a back side of the refrigerating chamber into the refrigerating chamber, an air-blowing fan conveying cold air to the duct unit, a refrigerating chamber damper device adjusting the amount of cold air flowing from the cooling chamber to the duct unit, an outside air temperature detector detecting outside air temperature, a refrigerating chamber temperature detector detecting the temperature inside the refrigerating chamber, and a controller operating the air-blowing fan and performing opening degree control of the refrigerating chamber damper device, the controller setting a specific opening degree for the opening degree of the refrigerating chamber damper device, based on a measured outside air temperature, which is the outside air temperature detected by the outside air temperature detector, comparing, in a state in which the air-blowing fan is being driven, a measured refrigerating chamber temperature, which is the temperature inside the refrigerating chamber detected by the refrigerating chamber temperature detector with a predetermined first refrigerating chamber setting

temperature, allowing the opening degree of the refrigerating chamber damper device to be in a fully-opened state when, based on a result of the comparison, the measured refrigerating chamber temperature is higher than the first refrigerating chamber setting temperature, comparing, in a state in which the air-
5 blowing fan is being driven, the measured refrigerating chamber temperature with a predetermined second refrigerating chamber setting temperature that is smaller than the first refrigerating chamber setting temperature, and allowing the opening degree of the refrigerating chamber damper device to be in a state of the specific opening degree when, based on a result of the comparison, the measured
10 refrigerating chamber temperature is lower than the second refrigerating chamber setting temperature" has been suggested (see, for example, Patent Literature 1).

Citation List

Patent Literature

15 [0004]

Patent Literature 1: Japanese Patent No. 5631284

Summary of Invention

Technical Problem

[0005]

20 However, the refrigerator described in Patent Literature 1 adjusts the degree of opening of the damper device to adjust the amount of air to the refrigerating chamber. That is, the refrigerator described in Patent Literature 1 causes the damper device to operate as resistance of an air passage of the refrigerating chamber to suppress the amount of air to the refrigerating chamber.
25 As a result, for example, to reduce the amount of air to the refrigerating chamber, the refrigerator described in Patent Literature 1 reduces the degree of opening of the damper device, that is, increases the air passage resistance, and therefore, a

region that cold air does not reach is generated at each position within the refrigerating chamber. Accordingly, the refrigerator described in Patent Literature 1 has a problem that temperature distribution is generated within the refrigerating chamber, and, especially, a pocket shelf part at a door of the refrigerating chamber is not thus cooled enough.

[0006]

The present invention has been designed to overcome the problems described above, and an object of the present invention is to obtain a refrigerator including an evaporator and an internal fan, the refrigerator being able to reduce the amount of power consumption while suppressing variations in the temperature of each storage chamber.

Solution to Problem

[0007]

A refrigerator according to an embodiment of the present invention includes a freezing chamber and at least one storage chamber different from the freezing chamber; a refrigeration cycle including a compressor, a condenser, an expansion mechanism, and an evaporator; an air passage communicating to the freezing chamber and the storage chamber different from the freezing chamber, the evaporator being arranged at the air passage; an internal fan provided at the air passage and configured to supply air cooled by the evaporator to the freezing chamber and the storage chamber different from the freezing chamber; a damper provided at a supply port of the storage chamber different from the freezing chamber in the air passage and configured to open and close the supply port; and a controller configured to control, based on an internal load, at least the damper, the controller including an internal load recognizing unit configured to recognize the internal load, an opening time acquisition unit configured to acquire an opening time during which the supply port is opened within a specified time

serving as a control interval for the damper in a case where the internal load is less than or equal to a specified value, a determination unit configured to determine whether or not a load of the freezing chamber and a load of the storage chamber different from the freezing chamber are greater than the specified value, and a damper control unit configured to control, in a case where the internal load is less than or equal to the specified value, the damper to open the supply port for the opening time within the specified time, and control, in a case where the internal load is greater than the specified value and the internal load is the load of the freezing chamber, the damper to fully close the supply port for the specified time, and in a case where the internal load is greater than the specified value and the internal load is the load of the storage chamber different from the freezing chamber, the damper to fully open the supply port for the specified time.

Advantageous Effects of Invention

[0008]

According to an embodiment of the present invention, in a case where an internal load is less than or equal to a specified value (in a case where the internal load is low), by adjusting the time during which a supply port is opened within a specified time as a control interval for a damper, the temperature of a storage chamber different from a freezing chamber is maintained at a setting temperature. That is, according to an embodiment of the present invention, only an amount of air that keeps the temperature of the storage chamber different from the freezing chamber constant is conveyed to the storage chamber within the specified time, and variations in the temperature of the storage chamber is thus suppressed. Therefore, according to an embodiment of the present invention, in a case where the internal load is low, the amount of cold air supplied to the freezing chamber within the specified time may be increased compared to

a conventional refrigerator. Accordingly, the cooling capacity for the freezing chamber may be increased. Thus, the driving time of a compressor may be reduced compared to a conventional refrigerator, and power consumption may further be reduced compared to a conventional refrigerator. At this time,

5 according to an embodiment of the present invention, in reducing the amount of air to the storage chamber different from the freezing chamber, the time during which the supply port is opened within the specified time may be reduced.

Therefore, according to an embodiment of the present invention, in reducing the amount of air to the storage chamber different from the freezing chamber, the air
10 passage resistance is not increased. Accordingly, a region that cold air does not reach may be prevented from being generated in the storage chamber different from the freezing chamber. Furthermore, temperature distribution may be prevented from being generated within the storage chamber different from the freezing chamber.

15 [0009]

Furthermore, according to an embodiment of the present invention, in a case where the internal load is greater than the specified value (in a case where the internal load is high), the damper is controlled to fully close the supply port for the specified time when the load of the freezing chamber is greater than the
20 specified value and to fully open the supply port for the specified time when the load of the storage chamber different from the freezing chamber is greater than the specified value. Therefore, according to an embodiment of the present invention, even in a case where the internal load is greater than the specified value, variations in the temperature of each storage chamber may be suppressed
25 (stabilization and cooling capacity may be maintained).

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a diagram explaining a configuration of a refrigeration cycle of a refrigerator 100 according to Embodiment of the present invention.

[Fig. 2] Fig. 2 is a diagram illustrating a cold air circuit of the refrigerator 100 according to Embodiment of the present invention.

5 [Fig. 3] Fig. 3 is a diagram explaining a specified time CT of a refrigerating chamber damper 23 of the refrigerator 100 according to Embodiment of the present invention.

[Fig. 4] Fig. 4 is a flowchart illustrating a flow until opening time control for the refrigerating chamber damper 23 of the refrigerator 100 according to
10 Embodiment of the present invention within the specified time is executed.

Description of Embodiments

[0011]

Hereinafter, a refrigerator according to Embodiment of the present invention will be described with reference to drawings. The present invention is
15 not intended to be limited to Embodiment described below. In the drawings provided below including Fig. 1, the size relationship of individual component members may differ from the actual size relationship.

[0012]

Embodiment.

20 Fig. 1 is a diagram explaining a configuration of a refrigeration cycle of a refrigerator 100 according to Embodiment of the present invention. The configuration of the refrigeration cycle of the refrigerator 100 will be described below with reference to Fig. 1.

The refrigerator 100 cools inside the refrigerator 100 to a setting
25 temperature by using a vapor-compression refrigeration cycle. Such a refrigeration cycle is configured such that a compressor 11, a condensing pipe 14, which serves as a condenser, a dew condensation prevention pipe 15, a drier

16, a capillary tube 17, which is a pressure-reducing mechanism, and an evaporator 18, which is a cooler, are connected by pipes. Furthermore, at the refrigeration cycle of the refrigerator 100, a heat exchange part 19 that allows heat exchange between refrigerant flowing in the capillary tube 17 and refrigerant
5 flowing in a pipe (suction pipe) provided between the evaporator 18 and the compressor 11 is provided. Furthermore, at the refrigeration cycle, a temperature sensor 18a, such as a thermistor, for measuring the temperature of refrigerant on an inlet side of the evaporator 18 and a temperature sensor 18b, such as a thermistor, for measuring the temperature of refrigerant on an outlet
10 side of the evaporator 18 are provided.

[0013]

The compressor 11 is, for example, arranged inside a machine chamber provided in a lower part of a rear surface of the refrigerator 100. The compressor 11 compresses refrigerant into high-temperature and high-pressure refrigerant and is driven by an inverter, and the operation capacity is controlled in
15 accordance with conditions.

[0014]

The condensing pipe 14 represents a condensing pipe buried on a top surface, a side surface, a rear surface, or other surfaces of the refrigerator 100 via an insulating material. Furthermore, the condensing pipe 14 also includes a
20 hot pipe for drain evaporation.

[0015]

The dew condensation prevention pipe 15 is connected between the condensing pipe 14 and the drier 16. The dew condensation prevention pipe 15 is provided for prevention of dew attachment to a front surface of the main body
25 of the refrigerator 100.

[0016]

The drier 16 is connected between the dew condensation prevention pipe 15 and the capillary tube 17. The drier 16 includes a filter for preventing dust, metal powder, or other materials within the refrigeration cycle of the refrigerator 100 from flowing into the compressor 11, an adsorption member that adsorbs moisture within the refrigeration cycle, and other components.

[0017]

The capillary tube 17 is connected between the drier 16 and the evaporator 18. The capillary tube 17 operates as a pressure-reducing mechanism for reducing the pressure of refrigerant flowing through the drier 16.

[0018]

The evaporator 18 is connected between the capillary tube 17 and a suction pipe side of the heat exchange part 19. The evaporator 18 cools inside air, for example, at an evaporator installation chamber provided on the rear surface side of the refrigerator 100. Above the evaporator 18, an internal fan 20 is provided. By the internal fan 20, cold air is supplied from the evaporator 18, and cold air is conveyed to each storage chamber.

[0019]

The heat exchange part 19 is a part that allows heat exchange between refrigerant flowing in the capillary tube 17 and refrigerant sucked into the compressor 11.

[0020]

Furthermore, for example, in an upper part of the rear surface of the refrigerator 100, the controller 10 including a microcomputer or other devices for controlling the operation of the refrigerator 100 is provided. Furthermore, the controller 10 includes an internal load recognizing unit 10a, an opening time acquisition unit 10b, a determination unit 10c, and a damper control unit 10d. The internal load recognizing unit 10a recognizes whether or not the internal load

of the refrigerator 100 is less than or equal to a specified value. The opening time acquisition unit 10b acquires, when the internal load is less than or equal to the specified value, an opening time during which a supply port 2 of a refrigerating chamber 22 is opened within a specified time, which is a control interval for a refrigerating chamber damper 23. The refrigerating chamber damper 23 and the supply port 2 of the refrigerating chamber 22 will be described later with reference to Fig. 2. The determination unit 10c determines whether or not the load of a freezing chamber 21 and the load of the refrigerating chamber 22 (a storage chamber different from the freezing chamber 21) is greater than the specified value. The damper control unit 10d controls the refrigerating chamber damper 23.

[0021]

In the refrigerator 100 configured as described above, the refrigerant that has turned into high-temperature and high-pressure refrigerant at the compressor 11 transfers heat to the outside air through the condensing pipe 14 and the dew condensation prevention pipe 15 (or part of the refrigerant remains in the refrigerator). The refrigerant whose heat has been sufficiently transferred is decompressed into low-temperature and low-pressure refrigerant at the capillary tube 17, receives heat at the evaporator 18 from air returning from each storage chamber, and is compressed into high-temperature and high-pressure refrigerant again at the compressor 11.

[0022]

Fig. 2 is a diagram illustrating a cold air circuit of the refrigerator 100 according to Embodiment of the present invention.

The refrigerator 100 includes the freezing chamber 21 and the refrigerating chamber 22 as a storage chamber different from the freezing chamber 21. In Fig. 2, only two storage chambers, that is, the freezing chamber 21 and the

refrigerating chamber 22, are illustrated. However, in addition to the above storage chambers, an ice-making chamber, a vegetable chamber, a switching chamber, and other chambers may be installed in parallel to the freezing chamber 21 and the refrigerating chamber 22 or in series to the refrigerating chamber 22 (not illustrated in Fig. 2). In Fig. 2, the refrigerating chamber 22, which is a storage chamber having the largest capacity in the refrigerator 100, and the freezing chamber 21, which has the lowest temperature zone, are illustrated.

[0023]

An air passage 1 at which the evaporator 18 and the internal fan 20 are provided connects the above storage chambers via supply ports. That is, cold air cooled by the evaporator 18 (cooled air) is conveyed by the internal fan 20 to each storage chamber. More particularly, the flow of cold air from the internal fan 20 is caused to branch off into individual storage chambers. One part of the entire amount of air is supplied to the freezing chamber 21, and the other part is supplied to the refrigerating chamber 22. Then, the air returns to the evaporator 18 again.

[0024]

At the supply port 2 of the refrigerating chamber 22 in the air passage 1, the refrigerating chamber damper 23 for opening and closing the supply port 2 is provided. The refrigerating chamber damper 23 is configured such that time control is performed on opening and closing of the refrigerating chamber damper 23 by the controller 10. That is, the controller 10 may adjust (control) the opening time during which the supply port 2 is opened within a specified time CT by controlling the opening time of the refrigerating chamber damper 23. That is, for the refrigerating chamber 22, the amount of cold air within the specified time CT is adjusted and the temperature of the refrigerating chamber is thus adjusted

by the control of the opening time of the refrigerating chamber damper 23. The temperature of the refrigerating chamber 22 is measured by a temperature sensor 22b, such as a thermistor, provided at the refrigerating chamber 22.

Then, the opening time acquisition unit 10b of the controller 10 acquires (predicts) a necessary opening time within the specified time CT of the refrigerating chamber damper 23, based on the measured temperature. That is, the opening time acquisition unit 10b acquires (predicts) how long within the specified time CT the supply port 2 needs to be opened so that the temperature of the refrigerating chamber 22 may be kept constant. Furthermore, the damper control unit 10d of the controller 10 controls the refrigerating chamber damper 23 such that the supply port 2 is opened only for the necessary opening time within the specified time CT. The above necessary opening time is predicted, for example, by a prediction technique such as PI control (proportional-integral control). During the opening time, the opening ratio of the supply port 2 by the refrigerating chamber damper 23 is set such that a region that cold air does not reach is not generated within the refrigerating chamber 22 due to a large air passage resistance. The opening ratio of the supply port 2 by the refrigerating chamber damper 23 is set, for example, to be fully open.

[0025]

Specifically, in Embodiment, the necessary opening time within the specified time CT of the refrigerating chamber damper 23 is obtained using equation (1).

$$MV = K_p \times [1 + \{1/(TI \times S)\}] \times EV \cdots (1)$$

In equation (1), MV represents the amount of operation, and is an opening time within the specified time CT of the refrigerating chamber damper 23. EV represents a control deviation, which is a difference between a setting temperature of the refrigerating chamber 22 and a measured value of the

temperature sensor 22b provided at the refrigerating chamber 22. Furthermore, K_p represents a proportional gain, T_I represents an integration time, and S represents a Laplace operator.

[0026]

5 Furthermore, the temperature of the freezing chamber 21 is measured by a temperature sensor 21b, such as a thermistor, provided at the freezing chamber 21.

10 In the case where a damper is provided at a supply port of the freezing chamber 21 in the air passage 1, advantages of the present invention may be attained.

[0027]

15 Next, the specified time CT will be described. The specified time CT is the shortest control interval at which the controller 10 controls the refrigerating chamber damper 23. The controllability improves as the specified time CT decreases. However, the specified time CT may be set in a desired manner.

[0028]

20 Fig. 3 is a diagram explaining the specified time CT for the refrigerating chamber damper 23 in the refrigerator 100 according to Embodiment of the present invention. The horizontal axis of Fig. 3 represents the specified time CT , and a more right position on the horizontal axis represents a larger specified time CT . The vertical axis of Fig. 3 represents input (input power), and an upper position on the vertical axis represents a larger input.

[0029]

25 As illustrated in Fig. 3, the number of times of driving the refrigerating chamber damper 23 increases as the specified time CT decreases (that is, the control interval decreases), and therefore, the amount of input necessary for opening and closing the refrigerating chamber damper 23 (damper input in Fig.

3) increases. In contrast, the shorter the specified time CT, the more the variations in the temperature of each storage chamber may be suppressed, and the more the amount of air to the freezing chamber 21 becomes, as described later. Therefore, the average input of the compressor 11 (compressor input in Fig. 3) decreases. Thus, as shown in Fig. 3, the entire input of the refrigerator 100, which is the total sum of input of a driving device such as the refrigerating chamber damper 23, input of the compressor 11, and other inputs has a minimum value. That is, by operating the refrigerating chamber damper 23 for the specified time CT, for which the entire input is at the minimum, the power consumption of the refrigerator 100 may further be reduced. Therefore, in Embodiment, the specified time CT by which the entire input is minimum is adopted. The specified time CT differs according to the operation conditions, internal capacity, and insulating structure of the refrigerator 100. Taking into consideration the number of times of driving the refrigerating chamber damper 23, the specified time CT is desirably set to about five minutes.

[0030]

Next, the opening time of the supply port 2 within the specified time CT at a stable state of the refrigerator 100 will be described. The stable state of the refrigerator 100 refers to a state in which the internal load, which will be described later, is less than or equal to a specified value, that is, the internal load is lower than a reference value.

[0031]

The controller 10 of the refrigerator 100 starts the compressor 11 when the temperature of the freezing chamber 21 reaches a setting temperature or above, and stops the compressor 11 when the temperature of the freezing chamber 21 drops to the setting temperature or below. The compressor 11, which occupies most of the entire input, needs to be stopped to reduce the amount of power

consumption by the refrigerator 100. Thus, by increasing the cooling capacity for the freezing chamber 21, that is, by increasing the amount of air supplied to the freezing chamber 21 as much as possible, the freezing chamber 21 is set to the setting temperature or below in a short time, and the operation time of the compressor 11 is reduced.

[0032]

With a conventional refrigerator, in opening and closing of the refrigerating chamber damper 23, the amount Q_{ra} of air is supplied to the refrigerating chamber 22 to reduce the temperature of the refrigerating chamber 22 at the time when the refrigerating chamber damper 23 is opened. At this time, the amount Q_{fa} of cold air, which is obtained by subtracting Q_{ra} from the entire amount Q of air, is supplied to the freezing chamber 21 (i.e. $Q_{fa} = Q - Q_{ra}$). Therefore, the temperature of the freezing chamber 21 is constant or increases.

[0033]

After the refrigerating chamber 22 is cooled to the setting temperature, the refrigerating chamber damper 23 is closed, and the entire amount Q of air is conveyed to the freezing chamber 21. Therefore, the freezing chamber 21 is cooled to the setting temperature, and then the compressor 11 stops.

[0034]

In contrast, with the refrigerator 100 according to Embodiment, the controller 10 controls the refrigerating chamber damper 23 to control the opening time during which the supply port 2 is opened within the specified time CT . That is, the refrigerator 100 according to Embodiment supplies the amount Q_{rb} of cold air, which corresponds to an amount that keeps the temperature of the refrigerating chamber 22 constant, to the refrigerating chamber 22 for the specified time CT . As is clear from the amount of reduction in the temperature of the refrigerating chamber 22, Q_{rb} is smaller than Q_{ra} . Consequently, in

Embodiment, the amount of air conveyed to the freezing chamber 21 is represented by $Q_{fb} = Q - Q_{rb}$, where Q_{fb} is larger than Q_{fa} . Therefore, the temperature of the freezing chamber 21 rapidly decreases compared to variations in the temperature of the conventional freezing chamber 21. Thus, inventors have obtained a result that the refrigerator 100 according to Embodiment achieves an improved operation ratio, which represents the ratio of operation to stoppage of the compressor 11, compared to a conventional refrigerator. Such a reduction ratio differs according to the operation conditions, internal capacity, and insulating structure of the refrigerator 100.

[0035]

With the refrigerator 100 according to Embodiment, in reducing the amount of cold air (amount of air) supplied to the refrigerating chamber 22, the time during which the supply port 2 is opened within the specified time CT may be reduced. Therefore, with the refrigerator 100 according to Embodiment, in reducing the amount of air to the refrigerating chamber 22, the air passage resistance is not increased, and therefore, a region that cold air does not reach may be prevented from being generated in the refrigerating chamber 22, and temperature distribution may be prevented from being caused in the refrigerating chamber 22.

[0036]

As described above, the shorter the specified time CT , the more the temperature constant control for the refrigerating chamber 22 may be achieved. However, the number of operation times of the refrigerating chamber damper 23 increases. Therefore, driving input of the refrigerating chamber damper 23 increases, and the possibility that the refrigerating chamber damper 23 is broken down due to its lifetime and other reasons increases. Furthermore, as the number of operation times of the refrigerating chamber damper 23 increases, the

amount of heat generation of a motor for causing the refrigerating chamber damper 23 to operate also increases and serves as an internal load, and the amount of power consumption by the refrigerator 100 increases. Therefore, by adopting the specified time CT by which the entire input of the refrigerator 100 is minimum, a further reduction in the amount of power consumption may be achieved. Furthermore, inventors have achieved a further improvement by performing similar control for a storage chamber different from the refrigerating chamber 22.

[0037]

As described above, by controlling the opening time during which the supply port 2 is open within the specified time CT for each of the storage chambers including the refrigerating chamber 22 but not including the freezing chamber 21 at a stable state to increase the amount of air to the freezing chamber 21, a reduction in the amount of power consumption may be achieved.

[0038]

Although damper control for the refrigerating chamber 22 has been described above, in the case where the damper control is performed for a plurality of storage chambers at the same time, the storage chambers may mutually receive disturbance at the time of damper control, and therefore, controllability of the temperature of the storage chambers may be degraded. Thus, control is desirably started in order from a damper provided at a supply port (cold air supply port) of a storage chamber with a high setting temperature. This is because for a storage chamber with a higher setting temperature, the temperature of air flowing into the evaporator 18 (cooler) increases, the influence exerted on the temperature of cold air supplied by the evaporator 18 (cooler) increases, and more disturbance tends to occur.

[0039]

At this time, since the refrigerating chamber 22 is a storage chamber having the largest capacity, control for the refrigerating chamber damper 23 provided at the supply port 2 of the refrigerating chamber 22 may be started first, and then, control may be performed in order from a damper provided at a supply port (cold air supply port) of a storage chamber with a high setting temperature. For a refrigerator including the refrigerating chamber 22, an ice-making chamber, a switching chamber, the freezing chamber 21, and a vegetable chamber, as an example, the order in which control is to be performed will be described below. In general, a vegetable chamber is a storage chamber with the highest setting temperature, and the refrigerating chamber 22 is a storage chamber having the largest capacity. Therefore, the refrigerating chamber 22 is provided with the highest priority. The vegetable chamber, which has the highest setting temperature, is provided with the second highest priority. The ice-making chamber and the switching chamber may have any setting temperature set by a user. Therefore, the order is determined by the setting temperature. In general, the ice-making chamber is set to have a temperature substantially close to the freezing chamber, and therefore is given a low priority.

[0040]

Next, examples of detection of the internal load of the refrigerator 100 will be explained.

[0041]

(1-1) Detection of internal load based on operation conditions of compressor

Operation/stoppage of the compressor 11 according to Embodiment is controlled based on the temperature detected by the temperature sensor 21b of the freezing chamber 21, and during operation, the rotation speed of the compressor 11 is controlled in accordance with the state of a deviation between the temperature of the freezing chamber 21 and a setting temperature, and the

operation time. Therefore, the operation conditions of the compressor 11 may be represented as one of indicators indicating the entire cooling load of the refrigeration cycle of the refrigerator 100, that is, the internal load. Thus, as the internal load, the rotation speed f of the compressor 11 or the input power W to the compressor 11 may be used. In the case where the rotation speed f of the compressor 11 is higher than a predetermined threshold (in the case where the input power W is large), the internal load is high. In the case where the rotation speed of the compressor 11 is lower than the predetermined threshold (in the case where the input power W is small), the internal load is low. The controller 10 determines whether or not the internal load is less than or equal to a threshold Q_a (specified value) by acquiring the rotation speed f or the input power W , which is acquired when controlling the operation of the compressor 11, and comparing the acquired value with a threshold stored in advance in a microcomputer. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) is performed by the internal load recognizing unit 10a.

[0042]

(1-2) Detection of internal load based on difference in temperature between outlet and inlet of evaporator

A state in which the temperature of air flowing into the evaporator 18 according to Embodiment represents a state in which the internal load is high. In this case, a temperature difference ΔT_e occurs between refrigerant on the outlet side of the evaporator 18 and refrigerant on the inlet side of the evaporator 18. Therefore, the temperature difference ΔT_e between the outlet side and the inlet side of the evaporator 18 may be regarded as one of indicators indicating the entire cooling load of the refrigeration cycle of the refrigerator 100, that is, the internal load. Thus, as the internal load, the temperature difference ΔT_e

between the outlet side and the inlet side of the evaporator 18 may be used.

The controller 10 determines whether or not the internal load is less than or equal to the threshold Q_a by acquiring output from the temperature sensor 18a, which is provided on the inlet side of the evaporator 18, and output from the temperature sensor 18b, which is provided on the outlet side of the evaporator 18, and comparing the temperature difference ΔT_e with a threshold stored in advance in a microcomputer. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) using the temperature sensors 18a and 18b is performed by the internal load recognizing unit 10a.

[0043]

(1-3) Detection of internal load based on number R_r of times of opening and closing door of refrigerating chamber.

By opening a door 22a of the refrigerating chamber 22, outside air flows into the refrigerating chamber 22, and cold air flows to the outside. Therefore, the temperature of the refrigerating chamber 22 increases, and the cooling load increases. The refrigerating chamber 22 is a region with the largest capacity in the refrigerator 100, and a large amount of cold air is necessary for cooling the refrigerating chamber 22 to a predetermined temperature. Therefore, the number R_r of times of opening and closing the door of the refrigerating chamber 22 may be regarded as one of indicators indicating the entire cooling load of the refrigeration cycle of the refrigerator 100, that is, the internal load. Thus, as the internal load, the number R_r of times of opening and closing the door per unit time may be used. The controller 10 determines whether or not the internal load is less than or equal to the threshold Q_a by counting the number R_r of times of opening and closing the door per unit time based on output from a door opening and closing sensor 22c of the refrigerating chamber 22 and comparing a

predetermined threshold stored in advance in a microcomputer with the number R_r of times of opening and closing the door. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) using the door opening and closing sensor 22c of the refrigerating chamber 22 is performed by the internal load recognizing unit 10a.

[0044]

(1-4) Detection of internal load based on number R_f of times of opening and closing door of freezing chamber

Similarly, the number R_f of times of opening and closing a door 21a of the freezing chamber 21 may be regarded as one of indicators indicating the entire cooling load of the refrigeration cycle of the refrigerator 100, that is, the internal load. That is, as described above, operation and stoppage of the compressor 11 according to Embodiment is controlled based on the temperature detected by the temperature sensor 21b of the freezing chamber 21. Thus, similarly to the number R_r of times of opening and closing the door of the refrigerating chamber 22, as the internal load, the number R_f of times of opening and closing the door per unit time may be used. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) using a door opening and closing sensor 21c provided at the freezing chamber 21 is performed by the internal load recognizing unit 10a.

[0045]

(1-5) Detection of internal load based on time τ_r during which door of refrigerating chamber is opened

As described above, by opening the door 22a of the refrigerating chamber 22, the temperature of the refrigerating chamber 22 increases, and therefore, the cooling load increases. Thus, the time τ_r during which the door of the refrigerating chamber 22 is opened (cumulative of time during which the door 22a

is opened per unit time) may be regarded as one of indicators indicating the entire cooling load of the refrigeration cycle of the refrigerator 100, that is, the internal load. Accordingly, as the internal load, the time τ_r during which the door of the refrigerating chamber 22 is opened may be used. The controller 10 counts and accumulates times during which the door 22a is opened, based on output from the door opening and closing sensor 22c. Then, the controller 10 determines whether or not the internal load is less than or equal to the threshold Q_a by comparing the time τ_r during which the door is opened per unit time with a predetermined threshold stored in advance in a microcomputer. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) using the door opening and closing sensor 22c provided at the refrigerating chamber 22 is performed by the internal load recognizing unit 10a.

[0046]

(1-6) Detection of internal load based on time τ_f during which door of freezing chamber is opened

Similarly, the time τ_f during which the door 21a of the freezing chamber 21 is opened may also be regarded as one of indicators indicating the entire cooling load of the refrigeration cycle of the refrigerator 100, that is, the internal load.

Thus, similarly to the time τ_r during which the door of the refrigerating chamber 22 is opened, as the internal load, the time τ_f during which the door is opened per unit time may be used. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) using the door opening and closing sensor 21c provided at the freezing chamber 21 is performed by the internal load recognizing unit 10a.

[0047]

(1-7) Detection of internal load based on temperature T_r of refrigerating chamber

It can be said that the higher the temperature detected by the temperature sensor 22b provided at the refrigerating chamber 22, the higher the internal load of the refrigerating chamber 22. Thus, as the internal load, the temperature T_r of the refrigerating chamber may be used. The controller 10 determines whether or not the internal load is less than or equal to the threshold Q_a by comparing, based on output from the temperature sensor 22b of the refrigerating chamber 22, the temperature T_r of the refrigerating chamber with a predetermined threshold stored in advance in a microcomputer. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) using the temperature sensor 22b provided at the refrigerating chamber 22 is performed by the internal load recognizing unit 10a.

[0048]

(1-8) Detection of internal load based on amount of reduction in temperature of freezing chamber

In the case where a large food having a relatively high temperature is placed in the freezing chamber 21, the speed of reduction in the temperature of the freezing chamber 21 tends to be slow. In such a case, it may be said that the cooling load in the freezing chamber 21 is high. Thus, as the internal load, the amount of reduction in the temperature of the freezing chamber 21 per unit time may be used. The controller 10 determines whether or not the internal load is less than or equal to the threshold Q_a by calculating the amount of reduction in the temperature per unit time, based on output from the temperature sensor 21b of the freezing chamber 21, and comparing the amount of reduction in the temperature with a predetermined threshold stored in advance in a microcomputer. The determination as to whether or not the internal load is less than or equal to the threshold Q_a (specified value) using the temperature sensor

21b provided at the freezing chamber 21 is performed by the internal load recognizing unit 10a.

[0049]

Each of the above-described examples of an internal load detector may be implemented without providing an additional component, and the number of components of the refrigerator 100 does not need to be increased.

[0050]

Next, control for the refrigerating chamber damper 23 in a state in which the above internal load is more than the threshold Q_a (specified value) will be described. When the state in which the internal load is more than the threshold Q_a (specified value) is detected, the controller 10 of the refrigerator 100 controls the refrigerating chamber damper 23 in accordance with a flow illustrated in a flowchart of Fig. 4. Fig. 4 is a flowchart illustrating a flow up to the point where opening time control within the specified time CT of the refrigerating chamber damper 23 at the stable state of the refrigerator 100 according to Embodiment of the present invention is executed. By performing a similar determination for a storage chamber different from the refrigerating chamber, opening time control at the stable state of the refrigerator 100 according to Embodiment may be attained.

[0051]

In the case where the internal load is more than the threshold Q_a (specified value) (step S1), the controller 10 compares the temperature T_r of the refrigerating chamber of the refrigerating chamber 22 with a setting temperature T_{rm} (step S2). This comparison is performed by the determination unit 10c of the controller 10. When T_r is less than or equal to T_{rm} , the internal load is of the freezing chamber 21 not the refrigerating chamber 22, that is, the load of the freezing chamber 21 is greater than the specified value. Therefore, the damper control unit 10d of the controller 10 controls the refrigerating chamber damper 23

to constantly close (fully close) the supply port 2 for the specified time CT (step S3). Accordingly, substantially the entire amount of air from the internal fan 20 of the refrigerator 100 may be supplied to the freezing chamber 21, and the load may be rapidly handled. Thus, the freezing chamber 21 may be cooled to the setting temperature. At this time, the rotation speed of at least one of the internal fan 20 and the compressor 11 may be increased at the same time, so that the cooling speed may be increased (from No in step S4 to step S5).

[0052]

After the freezing chamber 21 is cooled to the setting temperature (Yes in step S4), the damper control unit 10d of the controller 10 performs control equivalent to the stable state for the refrigerating chamber damper 23 (step S6).

[0053]

In contrast, when T_r is greater than T_{rm} in step S2, the internal load is of the refrigerating chamber 22, that is, the load of the refrigerating chamber 22 is greater than the specified value. Therefore, the damper control unit 10d of the controller 10 controls the refrigerating chamber damper 23 to constantly fully open the supply port 2 for the specified time CT (step S11). Accordingly, the load of the refrigerating chamber 22 is handled, and the refrigerating chamber 22 is cooled to the setting temperature. At this time, the rotation speed of at least one of the internal fan 20 and the compressor 11 may be increased at the same time, so that the cooling speed may be increased (from No in step S12 to step S13). After the freezing chamber 21 is cooled to the setting temperature (Yes in step S12), the damper control unit 10d of the controller 10 performs control equivalent to the stable state for the refrigerating chamber damper 23 (step S14).

[0054]

As described above, with the refrigerator 100 according to Embodiment, in the case where the internal load is less than or equal to the specified value (in

the case where the internal load is low), by adjusting the time during which the supply port is opened within the specified time, which is a control interval for the damper, the temperature of a storage chamber different from the freezing chamber 21 is maintained at the setting temperature, in a manner different from a conventional structure in which the supply port of the storage chamber different from the freezing chamber 21 is opened or closed according to the setting temperature. That is, with the refrigerator 100 according to Embodiment, only an amount of cold air that keeps the temperature of the storage chamber different from the freezing chamber 21 constant is conveyed to the storage chamber for the specified time CT, and thus variations in the temperature of the storage chamber is suppressed. Therefore, in the case where the internal load is low, the refrigerator 100 according to Embodiment may increase the amount of cold air supplied to the freezing chamber 21 compared to a conventional refrigerator. Thus, variations in the temperature of the freezing chamber 21 may be suppressed. Accordingly, the driving time of the compressor 11 may be reduced compared to a conventional refrigerator, and therefore a further reduction in the power consumption may be achieved compared to a conventional refrigerator.

[0055]

At this time, with the refrigerator 100 according to Embodiment, in reducing the amount of air to the storage chamber different from the freezing chamber 21, the time during which the supply port is opened within the specified time CT may be reduced. Therefore, with the refrigerator 100 according to Embodiment, in reducing the amount of air to the storage chamber different from the freezing chamber 21, the air passage resistance is not increased. Therefore, a region that cold air does not reach may be prevented from being generated in the storage chamber different from the freezing chamber 21. Furthermore,

temperature distribution may be prevented from being caused in the storage chamber different from the freezing chamber 21.

[0056]

Furthermore, with the refrigerator 100 according to Embodiment, in the case where the internal load is greater than the specified value (in the case where the internal load is high), the damper is controlled to fully close the supply port for the specified time when the load of the freezing chamber 21 is greater than the specified value and to fully open the supply port for the specified time when the load of the storage chamber different from the freezing chamber 21 is greater than the specified value. Therefore, with the refrigerator 100 according to Embodiment, even in the case where the internal load is greater than the specified value, variations in the temperature of each storage chamber may be suppressed (stabilization and cooling capacity may be maintained).

Reference Signs List

[0057]

1 air passage, 2 supply port, 10 controller, 10a internal load recognizing unit, 10b opening time acquisition unit, 10c determination unit, 10d damper control unit, 11 compressor, 14 condensing pipe, 15 dew condensation prevention pipe, 16 drier, 17 capillary tube, 18 evaporator, 18a temperature sensor, 18b temperature sensor, 19 heat exchange part, 20 internal fan, 21 freezing chamber, 21a door, 21b temperature sensor, 21c door opening and closing sensor, 22 refrigerating chamber, 22a door, 22b temperature sensor, 22c door opening and closing sensor, 23 refrigerating chamber damper, 100 refrigerator

CLAIMS

[Claim 1]

A refrigerator comprising:

5 a freezing chamber and at least one storage chamber different from the freezing chamber;

a refrigeration cycle including a compressor, a condenser, an expansion mechanism, and an evaporator;

10 an air passage communicating to the freezing chamber and the storage chamber different from the freezing chamber, the evaporator being arranged at the air passage;

an internal fan provided at the air passage and configured to supply air cooled by the evaporator to the freezing chamber and the storage chamber different from the freezing chamber;

15 a damper provided at a supply port of the storage chamber different from the freezing chamber in the air passage and configured to open and close the supply port; and

a controller configured to control, based on an internal load, at least the damper,

the controller including

20 an internal load recognizing unit configured to recognize the internal load, an opening time acquisition unit configured to acquire an opening time during which the supply port is opened within a specified time serving as a control interval for the damper in a case where the internal load is less than or equal to a specified value,

25 a determination unit configured to determine whether or not a load of the freezing chamber and a load of the storage chamber different from the freezing chamber are greater than the specified value, and

a damper control unit configured to
control, in a case where the internal load is less than or equal to the
specified value, the damper to open the supply port for the opening time within
the specified time, and

5 control, in a case where the internal load is greater than the specified
value and the internal load is the load of the freezing chamber, the damper to
fully close the supply port for the specified time, and in a case where the internal
load is greater than the specified value and the internal load is the load of the
storage chamber different from the freezing chamber, the damper to fully open
10 the supply port for the specified time.

[Claim 2]

The refrigerator of claim 1,
wherein the specified time is a time for which an entire input of the
refrigerator is minimum.

15 [Claim 3]

The refrigerator of claim 1 or 2, wherein
the storage chamber different from the freezing chamber includes a
plurality of storage chambers, and the damper includes a plurality of dampers,
the storage chambers different from the freezing chamber include a
20 refrigerating chamber and at least one storage chamber different from the
refrigerating chamber, and

the damper control unit is configured to start control for the damper
provided at the supply port of the refrigerating chamber and then start control for
the damper provided at the supply port of the storage chamber different from the
25 refrigerating chamber.

[Claim 4]

The refrigerator of claim 3, wherein

the storage chamber different from the refrigerating chamber includes a plurality of storage chambers, and

in controlling the damper provided at the supply port of each of the storage chambers different from the refrigerating chamber, the damper control unit is configured to start control in order from the damper corresponding to a storage chamber having a high setting temperature.

[Claim 5]

The refrigerator of claim 1 or 2, wherein

the storage chamber different from the freezing chamber includes a plurality of storage chambers, and the damper includes a plurality of dampers, and

the damper control unit is configured to start control in order from the damper provided at the supply port of a storage chamber having a high setting temperature.

[Claim 6]

The refrigerator of any one of claims 1 to 5, further comprising:

a temperature sensor configured to detect a temperature of the storage chamber different from the freezing chamber,

wherein the determination unit is configured to

compare, in a state in which the internal load is greater than the specified value, the temperature detected by the temperature sensor with a specified value,

determine, in a case where the temperature detected by the temperature sensor is less than or equal to the specified value, that the load of the freezing chamber is greater than the specified value, and

determine, in a case where the temperature detected by the temperature sensor is greater than the specified value, that the load of the storage chamber different from the freezing chamber is greater than the specified value.

[Claim 7]

5 The refrigerator of any one of claims 1 to 6, wherein the internal load recognizing unit is configured to recognize the internal load, based on a rotation speed of the compressor or input power of the compressor.

[Claim 8]

 The refrigerator of any one of claims 1 to 6, further comprising:

10 a temperature sensor configured to measure a temperature of refrigerant on an outlet side of the evaporator; and

 a temperature sensor configured to measure a temperature of refrigerant on the outlet side of the evaporator,

15 wherein the internal load recognizing unit is configured to recognize the internal load, based on a difference in the temperature between the refrigerant on the outlet side of the evaporator and the refrigerant on the inlet side of the evaporator.

[Claim 9]

 The refrigerator of any one of claims 1 to 6, further comprising:

20 a door opening and closing sensor configured to detect an opening and closing state of a door of the storage chamber,

 wherein the internal load recognizing unit is configured to recognize the internal load, based on a number of times of opening and closing the door per unit time.

25 [Claim 10]

 The refrigerator of any one of claims 1 to 6, further comprising:

a door opening and closing sensor configured to detect an opening and closing state of a door of the storage chamber,

wherein the internal load recognizing unit is configured to recognize the internal load, based on a cumulative opening time of the door per unit time.

5 [Claim 11]

The refrigerator of any one of claims 1 to 6, further comprising:

a temperature sensor configured to detect a temperature of the storage chamber different from the freezing chamber,

10 wherein the internal load recognizing unit is configured to recognize the internal load, based on the temperature of the storage chamber.

[Claim 12]

The refrigerator of any one of claims 1 to 6, further comprising:

a freezing chamber temperature sensor configured to detect a temperature of the freezing chamber,

15 wherein the internal load recognizing unit is configured to recognize the internal load, based on an amount of reduction in the temperature of the freezing chamber per unit time.

[Claim 13]

20 The refrigerator of any one of claims 1 to 12, wherein in a case where the internal load is greater than the specified value, the controller is configured to increase a rotation speed of at least one of the compressor and the internal fan.