DESCRIPTION

Title of Invention

REFRIGERATOR AND METHOD OF CONTROLLING FLOW RATE OF REFRIGERANT

Technical Field

[0001]

The present invention relates to a refrigerator configured to control a flow rate of refrigerant, and a method of controlling a flow rate of refrigerant.

Background Art

[0002]

A typically known refrigerator includes a storage compartment, a refrigerant circuit, a cooling compartment in which a cooler is disposed, a fan configured to send cooled air from the cooling compartment to the storage compartment, and an air passage connecting the cooling compartment and the storage compartment. In the refrigerant circuit, a compressor, a radiator, a decompression device (capillary tube), and the cooler are connected to each other via pipes. While the refrigerant is circulating inside the refrigerant circuit, the refrigerant repeatedly changes its state between states of evaporation, compression, condensation, and expansion, thereby cooling the storage compartment through heat transfer at the evaporation.

[0003]

In the conventional refrigerator, the flow rate of the refrigerant supplied to the cooler is determined by the rotational frequency of the compressor and the diameter of the capillary tube. The stroke volume of the compressor and the diameter of the capillary tube are calculated and determined on the basis of a maximum load point (for example, in summer) and a minimum load point (for example, in winter) of the refrigerator. When a capillary tube thus designed on the basis of the maximum load point and the minimum load point is used, adjustment of the flow rate of the refrigerant at any other load point necessarily depends only on the rotational frequency of the compressor. For example, at a low outside air temperature or a small internal load, the rotational frequency of the compressor is shifted to a lower

speed within an adjustable range to achieve a low flow rate of the refrigerant within an adjustable range, thereby reducing a workload on the compressor. However, when the amount of load is smaller than the lower limit of the adjustable range of the rotational frequency of the compressor, the flow rate of the refrigerant supplied to the cooler is not changed, and thus the density of refrigerant gas sucked into the compressor increases. Consequently, the load is increased on the compressor, preventing reduction in power consumption.

[0004]

To more appropriately adjust the flow rate of the refrigerant, Patent Literature 1 discloses a refrigerator including two capillary tubes having different diameters, and configured to switch the two capillary tubes depending on the outside air temperature or the amount of the internal load. Specifically, the refrigerator disclosed in Patent Literature 1 further includes a three-way valve connected to the two capillary tubes, and temperature sensors disposed at an inlet and an outlet of a cooling compartment. A temperature difference between the inlet and the outlet of the cooling compartment is calculated on the basis of outputs from these temperature sensors and compared to a target temperature difference to control the three-way valve to switch the two capillary tubes in accordance with a result of the comparison.

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2003-14357

Summary of Invention

Technical Problem

[0006]

However, with the configuration disclosed in Patent Literature 1, the switching of the two capillary tubes is only made between a pattern in which the refrigerant flows to one of the two capillary tubes, and a pattern in which the refrigerant flows to both of the capillary tubes. Thus, reduction in the power consumption cannot be

achieved at a load point other than a designed load point (for example, a case in which a door is opened and closed and an internal temperature abruptly increases). To solve this problem, a larger number of capillary tubes having different diameters can be used to achieve adjustment of the flow rate of the refrigerant for a larger number of load points; however, this configuration adversely results in an increased product cost.

[0007]

The present invention is intended to solve the above-described problem and provide a refrigerator that can achieve energy saving by appropriately adjusting the flow rate of refrigerant supplied to a cooler depending on the operation state of the refrigerator.

Solution to Problem
[0008]

A refrigerator according to an embodiment of the present invention includes a storage compartment, a refrigerant circuit in which a compressor, a radiator, a plurality of capillary tubes having different Cv values, a selecting unit configured to select at least one of the plurality of capillary tubes, and a cooler are connected to each other via pipes to circulate refrigerant, the refrigerant flowing through the at least one of the plurality of capillary tubes, a first sensor configured to output a first sensor value on the basis of detection of an evaporating temperature of the refrigerant or an evaporating pressure of the refrigerant, a second sensor configured to output a second sensor value on the basis of detection of at least one of a condensing temperature of the refrigerant and a condensing pressure of the refrigerant, and a controller configured to control the selecting unit on the basis of a flow rate of the refrigerant based on a rotational frequency of the compressor, the first sensor value, and the second sensor value, wherein the plurality of capillary tubes includes a first capillary tube having a first Cv value, and a second capillary tube having a second Cv value smaller than the first Cv value, wherein the selecting unit is configured to select one of a first stage in which the refrigerant flows to both of the first capillary tube and the second capillary tube, a second stage in which the refrigerant flows only to the first capillary tube, and a third stage in which the refrigerant flows only to the second capillary tube, and wherein the controller is configured to control the selecting unit to periodically select the first stage and the second stage alternately, or the second stage and the third stage alternately.

Advantageous Effects of Invention
[0009]

The refrigerator according to the embodiment of the present invention can supply a cooler with refrigerant of a flow rate suitable to the operation state of the

refrigerator by selecting at least one of the plurality of capillary tubes on the basis of, for example, the rotational frequency of the compressor, the evaporating temperature, and the condensing temperature. This configuration reduces overage and shortage of the flow rate of the refrigerant, thereby achieving a reduced load on the compressor and energy saving.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a schematic configuration diagram of a refrigerator in an embodiment of the present invention.

[Fig. 2] Fig. 2 is a structural diagram of a refrigerant circuit in the embodiment of the present invention.

[Fig. 3] Fig. 3 is a control block diagram of the refrigerator in the embodiment of the present invention.

[Fig. 4] Fig. 4 is a pattern diagram of a three-way valve in the embodiment of the present invention. Fig. 4 (a) illustrates passages in a first stage, Fig. 4 (b) illustrates passages in a second stage, Fig. 4 (c) illustrates passages in a third stage, and Fig. 4 (d) illustrates passages in a fourth stage.

[Fig. 5] Fig. 5 is a diagram illustrating an exemplary Cv value map in the embodiment of the present invention.

[Fig. 6] Fig. 6 is a flowchart of refrigerant flow rate control processing in the embodiment of the present invention.

[Fig. 7] Fig. 7 is a diagram for description of an exemplary passage selection through the three-way valve in the embodiment of the present invention.

[Fig. 8] Fig. 8 is a diagram for description of another exemplary passage selection through the three-way valve in the embodiment of the present invention.

Description of Embodiments

[0011]

An embodiment of a refrigerator and a method of controlling a flow rate of refrigerant in the present invention will be described below in detail with reference to the accompanying drawings.

[0012]

Fig. 1 is a schematic configuration diagram of a refrigerator 100 in an embodiment of the present invention, and Fig. 2 is a structural diagram of a refrigerant circuit 10 included in the refrigerator 100. The refrigerator 100 includes a plurality of storage compartments 9a and 9b formed inside a box (not illustrated), a fan 6, an air-flow controller 7, a cooling compartment 8 including a cooler 4, the refrigerant circuit 10, and a controller 50. An internal temperature sensor 21 configured to measure the temperature inside the storage compartment 9a is disposed in the storage compartment 9a, and an internal temperature sensor 22 configured to measure the temperature inside the storage compartment 9b is disposed in the storage compartment 9b. In addition, an evaporating temperature sensor 23 configured to detect an evaporating temperature of the refrigerant is disposed in the cooler 4, and a condensing temperature sensor 24 configured to detect a condensing temperature of the refrigerant is disposed in a radiator 2. The evaporating temperature sensor 23 and the condensing temperature sensor 24 correspond to a first sensor and a second sensor according to the present invention, respectively. The evaporating temperature and the condensing temperature detected by the evaporating temperature sensor 23 and the condensing temperature sensor 24 are output to the controller 50. The evaporating temperature and the condensing temperature correspond to a first sensor value and a second sensor value according to the present invention, respectively.

[0013]

As illustrated in Figs. 1 and 2, the refrigerant circuit 10 includes a compressor 1, the radiator 2, a capillary tube 3, the cooler 4, and a three-way valve 5. The compressor 1 compresses the refrigerant inside the refrigerant circuit 10. The radiator 2 condensates the refrigerant compressed by the compressor 1. The capillary tube 3 is a decompression device configured to decompress the refrigerant condensed by the radiator 2. In the present embodiment, the capillary tube 3 includes two capillary tubes 3a and 3b having different values for at least one of a diameter and a length. The capillary tubes 3a and 3b correspond to a first capillary

tube and a second capillary tube according to the present invention, respectively. The three-way valve 5 corresponds to a selecting unit according to the present invention, and includes one inlet passage 5a and two outlet passages 5b and 5c. The three-way valve 5 selects a passage for the refrigerant by opening and closing the two outlet passages 5b and 5c. The outlet passage 5b is connected to the capillary tube 3a, and the outlet passage 5c is connected to the capillary tube 3b. The cooler 4 evaporates the refrigerant decompressed through the capillary tube 3. The compressor 1, the radiator 2, the capillary tube 3, and the cooler 4 are sequentially connected to each other to form a refrigeration cycle of the refrigerator 100.

[0014]

In the refrigerator 100, high-temperature and high-pressure gas refrigerant discharged from the compressor 1 is sent to the radiator 2. In the radiator 2, the refrigerant exchanges heat with external air and condensates through heat transferring. The condensed high-pressure liquid refrigerant is decompressed through the capillary tube 3 to become low-pressure and low-temperature refrigerant. Then, the refrigerant flows into the cooler 4 disposed in the box of the refrigerator 100, and exchanges heat with air inside the cooling compartment 8. Consequently, the air inside the cooling compartment 8 is cooled by the refrigerant, and the refrigerant becomes low-pressure gas refrigerant. The air cooled at the cooling compartment 8 is sent by the fan 6 through air paths (arrows illustrated in Fig. 1) connected to the respective storage compartments 9a and 9b, and then flows into the respective storage compartments 9a and 9b. Consequently, the storage compartments 9a and 9b are cooled.

[0015]

The refrigerant cooled into low-pressure gas through the cooler 4 flows into the compressor 1. Then, the refrigerant is pressurized again through the compressor 1, and discharged as high-temperature and high-pressure gas refrigerant. The cooling air having cooled the storage compartments 9a and 9b flows into the cooling

compartment 8 again through a return air path, and is cooled through the cooler 4 again.

[0016]

Fig. 3 is a control block diagram of the refrigerator 100. The controller 50 is a control device, such as a microcomputer, and is connected to the internal temperature sensors 21 and 22, the evaporating temperature sensor 23, the condensing temperature sensor 24, the compressor 1, the three-way valve 5, the fan 6, and the air-flow controller 7. The controller 50 includes an air-flow control unit 51, a refrigerant flow rate control unit 52, and a storage unit 53. The air-flow control unit 51 changes the rotational frequency of the fan 6 or a manipulated variable of the air-flow controller 7 depending on values output from the internal temperature sensors 21 and 22 disposed in the storage compartments 9a and 9b, respectively. Consequently, the air flow of the cooling air is controlled and the temperature of the storage compartments 9a and 9b is adjusted. In the present embodiment, the internal temperature sensors 21 and 22 are disposed in all of the storage compartments 9a and 9b; however, the present invention is not limited to this configuration. At least one of the temperature sensors may be disposed in at least one storage compartment in which the temperature is controlled to be constant. The positions of the internal temperature sensors 21 and 22 are not limited to positions illustrated in Fig. 1. The internal temperature sensors 21 and 22 may be disposed at any positions to detect typical temperatures of the storage compartments 9a and 9b.

[0017]

The refrigerant flow rate control unit 52 adjusts the flow rate of the refrigerant supplied to the cooler 4 by controlling the three-way valve 5 on the basis of the values output from the evaporating temperature sensor 23 and the condensing temperature sensor 24, which detect the evaporating temperature of the refrigerant and the condensing temperature of the refrigerant, respectively, and controlling the rotational frequency of the compressor 1. Regarding the evaporating temperature sensor 23 and the condensing temperature sensor 24, in Fig. 1, the evaporating temperature sensor 23 is disposed at the cooler 4 and the condensing temperature sensor 24 is

disposed at the radiator 2; however, the present invention is not limited to this configuration. The evaporating temperature sensor 23 and the condensing temperature sensor 24 may be disposed at any positions to detect a typical evaporating temperature and a typical condensing temperature. For example, an outlet temperature of the cooler 4 may be measured by the evaporating temperature sensor 23 as the evaporating temperature. The storage unit 53 stores data necessary for control performed by the air-flow control unit 51 and the refrigerant flow rate control unit 52 (Cv values of the capillary tubes 3a and 3b, for example).

[0018]

Fig. 4 is a pattern diagram of the three-way valve 5 in the present embodiment. As illustrated in Fig. 4, the three-way valve 5 allows passage selection in four stages. Fig. 4 (a) illustrates passages in a first stage. In the first stage, the outlet passages 5b and 5c are both opened (fully opened). Thus, the refrigerant flows to both of the capillary tube 3a and the capillary tube 3b. Fig. 4 (b) illustrates passages in a second stage. In the second stage, the outlet passage 5b is opened, and the outlet passage 5c is closed. Thus, the refrigerant flows only to the capillary tube 3a connected to the outlet passage 5b. Fig. 4 (c) illustrates passages in a third stage. In the third stage, the outlet passage 5c is opened, and the outlet passage 5b is closed. Thus, the refrigerant flows only to the capillary tube 3b connected to the outlet passage 5c. Fig. 4 (d) illustrates passages in a fourth stage. In the fourth stage, the outlet passages 5b and 5c are both closed (fully closed). Thus, the refrigerant flows to none of the capillary tube 3a and the capillary tube 3b.

[0019]

When the refrigerant is excessively decompressed through the capillary tube 3 in a typical operation state (certain rotational frequency of the compressor, outside air temperature, and internal temperature) of the refrigerant circuit 10, the flow rate of the refrigerant flowing through the refrigerant circuit 10 decreases, resulting in an insufficient cooling capacity. On the other hand, when the refrigerant is inappropriately decompressed through the capillary tube 3, the flow rate of the refrigerant can be increased. However, in this case, a difference between the

pressure of the refrigerant inside the radiator 2 (high-pressure side) and the pressure inside the cooler 4 (low pressure) cannot be maintained, preventing sufficient cooling inside the refrigerator 100. In view of the above, a flow rate coefficient Cv is used as an amount of expansion for achieving an efficient operation of the refrigerant circuit 10. The Cv is expressed by Expression (1) below.

[0020]

[Expression 1]

$$Cv = \frac{aG}{\sqrt{\rho(Pc-Pe)}} \quad \cdots (1)$$

[0021]

G: flow rate [kg/h] ($\propto$ the rotational frequency of the compressor 1)

ρ: density of high-pressure liquid refrigerant [kg/m^3]

Pc: condensing pressure [MPa]

Pe: evaporating pressure [MPa]

a: constant [-]

[0022]

The condensing pressure Pc can be calculated from a value output from the condensing temperature sensor 24 configured to detect the condensing temperature, and the evaporating pressure Pe can be calculated from a value output from the evaporating temperature sensor 23 configured to detect the evaporating temperature. In the refrigerator 100, the refrigerant at an outlet of the radiator 2 is in a liquid state, and thus the density ρ of high-pressure liquid refrigerant can be calculated from the value output from the condensing temperature sensor 24 configured to detect the condensing temperature. The flow rate G can be calculated from the rotational frequency of the compressor 1. The constant "a" is a value from 0.30 to 0.45, which allows calculation of an appropriate Cv value.

[0023]

Fig. 5 illustrates relations between the Cv value obtained through Expression (1) (hereinafter referred to as "Cvp"), and the condensing pressure Pc, the evaporating pressure Pe, and the rotational frequency of the compressor 1 ($\propto$ the

flow rate G). Fig. 5 is an exemplary Cv value map, in which the horizontal axis represents the rotational frequency of the compressor 1 (flow rate), and the vertical axis represents the Cv value. In Fig. 5, the Cv value map with three examples ΔP_1, ΔP_2, and ΔP_3, which are the difference (Pc − Pe) between the condensing pressure and the evaporating pressure in the refrigerator 100, is shown. Specifically, ΔP_1 is 7.0 (MPa), ΔP_2 is 9.0 (MPa), and ΔP_3 is 11.4 (MPa).

[0024]

In Fig. 5, Cva represents the Cv value of the capillary tube 3a, and Cvb represents the Cv value of the capillary tube 3b. Each capillary tube has a different Cv value depending on the diameter and length of each capillary tube. As illustrated in Fig. 5, in the present embodiment, the Cv value (Cva) of the capillary tube 3a is larger than the Cv value (Cvb) of the capillary tube 3b (Cva > Cvb). A Cv value in the first stage (in which the refrigerant flows to both of the capillary tubes 3a and 3b) of the three-way valve 5 is the sum of Cva and Cvb (Cva + Cvb). Thus, the Cv values obtained by passage selection through the three-way valve 5 are in such a relation of the first stage (Cva + Cvb) > the second stage (Cva) > the third stage (Cvb).

[0025]

As illustrated in Fig. 5, the Cv value (Cvp) for an efficient operation of the refrigerant circuit 10 changes in proportion to the flow rate. However, as in the conventional technology, when the selection is only made between a pattern in which the refrigerant flows to one of the two capillary tubes 3a and 3b, and a pattern in which the refrigerant flows to both two capillary tubes 3a and 3b, the Cv value is fixed to any of Cva, Cvb and (Cva + Cvb). In view of the above, in refrigerant flow rate control processing according to the present embodiment, the three-way valve 5 is controlled to select between the capillary tubes 3a and 3b to achieve an appropriate Cv value (Cvp) for an operation state.

[0026]

The following describes the process of the refrigerant flow rate control processing in the present embodiment with reference to Figs. 6 to 8. Fig. 6 is a

flowchart of the refrigerant flow rate control processing in the present embodiment. This processing is started by the refrigerant flow rate control unit 52 of the controller 50 in response to, for example, opening and closing of a door of the refrigerator 100, change in the outside air temperature, or change in the rotational frequency of the compressor 1. As illustrated in Fig. 6, in the present processing, first, the evaporating temperature and the condensing temperature are acquired from the evaporating temperature sensor 23 and the condensing temperature sensor 24, respectively, and the rotational frequency is acquired from the compressor 1 (S1). Then, a target Cv value (Cvp) is calculated on the basis of Expression (1) from the condensing temperature, the evaporating temperature, and the rotational frequency thus acquired (S2). Subsequently, whether the Cvp is larger than the Cv value (Cva + Cvb) in the first stage is determined (S3).

[0027]

When the Cvp is larger than the Cv value (Cva + Cvb) in the first stage (YES at S3), the three-way valve 5 is fixed to the first stage illustrated in Fig. 4 (a) (S4). Thus, the refrigerant flows to both of the capillary tube 3a and the capillary tube 3b. When the Cvp is not larger than the Cv value (Cva + Cvb) in the first stage (NO at S3), whether the Cvp is not larger than the Cv value (Cvb) in the third stage is determined (S5). Then, when the Cvp is not larger than the Cv value (Cvb) in the third stage (YES at S5), the three-way valve 5 is fixed to the third stage illustrated in Fig. 4 (c) (S6). Thus, the refrigerant flows only to the capillary tube 3b.

[0028]

When the Cvp is larger than the Cv value (Cvb) in the third stage (NO at S5), whether the Cvp is larger than the Cv value (Cva) in the second stage is determined (S7). Then, when the Cvp is larger than the Cv value (Cva) in the second stage (YES at S7), the selection through the three-way valve 5 is alternately made between the first stage illustrated in Fig. 4 (a) and the second stage illustrated in Fig. 4 (b) in a predetermined period T (S8). Thus, the refrigerant alternately flows to both of the capillary tubes 3a and 3b and only to the capillary tube 3a. In this case, a duration T_1 of the first stage (during which the refrigerant flows to both of the capillary tubes 3a

and 3b) and a duration T_2 of the second stage (during which the refrigerant flows only to the capillary tube 3a) are set to be variable depending on the Cvp. Specifically, as indicated by Expression (2) below, the refrigerant flow rate control unit 52 sets the durations T_1 and T_2 so that the average of the Cv value over a period T ($T_1 + T_2$) is equal to the target Cv value (Cvp).

[0029]

[Expression 2]

$$Cvp = ((Cva + Cvb) \times T_1 + Cva \times T_2)/T \quad \ldots (2)$$

[0030]

Fig. 7 is a diagram for description of an exemplary passage selection through the three-way valve 5. In Fig. 7, the horizontal axis represents time, and the vertical axis represents the Cv value. In the example illustrated in Fig. 7, the Cv value (Cvp) calculated at S2 is close to the Cv value (Cva) in the second stage, and thus the duration T_2 of the second stage is set to be longer than the duration T_1 of the first stage. Fig. 8 is a diagram for description of another exemplary passage selection through the three-way valve 5. In Fig. 8, the horizontal axis represents time, and the vertical axis represents the Cv value. In the example illustrated in Fig. 8, the Cv value (Cvp) calculated at S2 is close to the Cv value (Cva + Cvb) in the first stage, and thus the duration T_1 of the first stage is set to be longer than the duration T_2 of the second stage. In both examples, the averaged Cv value over the period T is equal to Cvp. The predetermined period T may be set to be any time; however, setting of 600 seconds or longer can achieve an enough lifetime for the three-way valve 5 and efficient control of the three-way valve 5.

[0031]

As illustrated in Fig. 6, when Cvp is not larger than the Cv value (Cva) in the second stage (NO at S7), the selection through the three-way valve 5 is alternately made between the second stage illustrated in Fig. 4 (b) and the third stage illustrated in Fig. 4 (c) in the predetermined period T (S9). Thus, the refrigerant alternately flows to the capillary tube 3a and the capillary tube 3b. In this case, similarly to the processing at S8, the refrigerant flow rate control unit 52 sets the duration of the

second stage (during which the refrigerant flows only to the capillary tube 3a) and the duration of the third stage (during which the refrigerant flows only to the capillary tube 3b) so that the average of the Cv value over the period T is equal to the target Cv value (Cvp).

[0032]

As described above, in the refrigerator 100 according to the above-described embodiment, the refrigerant can be supplied at a flow rate suitable to an internal load by obtaining the target Cv value suitable to the operation state of the refrigerator 100 and selecting refrigerant passages (the capillary tubes 3a and 3b) through the three-way valve 5 to achieve the target Cv value. This configuration reduces overage and shortage of the refrigerant in the refrigerant circuit 10, thereby achieving a reduced load on the compressor 1 and reduced power consumption.

[0033]

The selection among the plurality of capillary tubes 3a and 3b through the three-way valve 5 allows fine flow rate control to appropriately adjust the flow rate of the refrigerant supplied to the cooler 4 at a load point other than any designed load point. Specifically, the flow rate of the refrigerant can be appropriately adjusted at a load point other than the designed point, when the target Cv value (Cvp) is not larger than the Cv value (Cva + Cvb) in the first stage and is larger than the Cv value (Cva) in the second stage, or when the Cv value (Cvp) is smaller than the Cv value (Cva) in the second stage and larger than the Cv value (Cvb) in the third stage. Thus, improved energy saving can be achieved at the refrigerator 100. In addition, the capillary tube 3 includes the two capillary tubes, which can achieve a reduced product cost and improved power consumption.

[0034]

The above describes the embodiment of the present invention; however, the present invention is not limited to the configuration in the above-described embodiment, and various modifications or combinations are possible without departing from the scope of the technical idea of the present invention. For example, in the above-described embodiment, the refrigerator 100 includes the one

cooler 4; however, the present invention is applicable to a refrigerator including a plurality of coolers.

[0035]

In the above-described embodiment, the evaporating pressure and the condensing pressure are calculated on the basis of values output from the evaporating temperature sensor 23 and the condensing temperature sensor 24; however, the present invention is not limited to this configuration. For example, an evaporating pressure sensor configured to detect the evaporating pressure and a condensing pressure sensor configured to detect the condensing pressure may be provided in place of (or, in addition to) the evaporating temperature sensor 23 and the condensing temperature sensor 24. The density ρ of high-pressure liquid refrigerant may be a fixed value stored in the storage unit 53 in advance.

[0036]

In the above-described embodiment, selection is made among the two capillary tubes 3a and 3b through the three-way valve 5; however, selection may be made among three or more capillary tubes through a selecting unit (four-way valve, for example) other than the three-way valve 5.

[0037]

In the above-described embodiment, the number of times of the selection through the three-way valve 5 is likely to increase, and thus a soundproof material may be provided around the three-way valve 5. With this configuration, improved quietness of the refrigerator 100 can be achieved to maintain comfort to a user.

[0038]

In addition, in the refrigerant flow rate control processing in the above-described embodiment, when the calculated Cv value (Cvp) is not larger than the Cv value (Cvb) in the third stage (YES at S5), the three-way valve 5 is fixed to the third stage illustrated in Fig. 4 (c) (S6); however, the present invention is not limited to this configuration. For example, selection through the three-way valve 5 may be alternately made between the third stage illustrated in Fig. 4 (c) and the fourth stage (in which the three-way valve 5 is fully closed) illustrated in Fig. 4 (d) in the period T.

Thus, a state in which the refrigerant flows only to the capillary tube 3b and a state in which the refrigerant flows to none of the capillary tubes are alternately selected. In this case, the duration of the third stage (during which the refrigerant flows only to the capillary tube 3b) and the duration of the fourth stage (during which the three-way valve is fully closed) are set depending on the calculated Cv value (Cvp) so that the average of the Cv value over the period T is equal to the target Cv value (Cvp). The target Cv value (Cvp) is not only calculated from Expression (1), but may be obtained from a table prepared in advance on the basis of the flow rate, the condensing pressure, and the evaporating pressure.

Reference Signs List

[0039]

1 compressor 2 radiator 3, 3a, 3b capillary tube 4 cooler 5 three-way valve 5a inlet passage 5b, 5c outlet passage 6 fan 7 air-flow controller 8 cooling compartment 9a, 9b storage compartment 10 refrigerant circuit 21, 22 internal temperature sensor 23 evaporating temperature sensor 24 condensing temperature sensor 50 controller 51 air-flow control unit 52 refrigerant flow rate control unit 53 storage unit 100 refrigerator

CLAIMS

[Claim 1]

A refrigerator comprising:

a storage compartment;

a refrigerant circuit in which a compressor, a radiator, a plurality of capillary tubes having different Cv values, a selecting unit configured to select at least one of the plurality of capillary tubes, and a cooler are connected to each other via pipes to circulate refrigerant, the refrigerant flowing through the at least one of the plurality of capillary tubes;

a first sensor configured to output a first sensor value on a basis of detection of an evaporating temperature of the refrigerant or an evaporating pressure of the refrigerant;

a second sensor configured to output a second sensor value on a basis of detection of at least one of a condensing temperature of the refrigerant and a condensing pressure of the refrigerant; and

a controller configured to control the selecting unit on a basis of a flow rate of the refrigerant based on a rotational frequency of the compressor, the first sensor value, and the second sensor value,

the plurality of capillary tubes including a first capillary tube having a first Cv value, and a second capillary tube having a second Cv value smaller than the first Cv value,

the selecting unit being configured to select one of a first stage in which the refrigerant flows to both of the first capillary tube and the second capillary tube, a second stage in which the refrigerant flows only to the first capillary tube, and a third stage in which the refrigerant flows only to the second capillary tube,

the controller being configured to control the selecting unit to periodically select the first stage and the second stage alternately, or the second stage and the third stage alternately.

[Claim 2]

The refrigerator of claim 1, wherein the controller is configured to calculate a target Cv value on a basis of the flow rate of the refrigerant based on the rotational frequency of the compressor, the first sensor value, and the second sensor value, and control the selecting unit on a basis of the calculated target Cv value.

[Claim 3]

The refrigerator of claim 2, wherein the controller is configured to control the selecting unit so that an average of the Cv values of the plurality of capillary tubes is equal to the target Cv value.

[Claim 4]

The refrigerator of claim 2 or 3, wherein the controller is configured to control the selecting unit to periodically select the first stage and the second stage alternately when the target Cv value is not larger than a sum of the first Cv value and the second Cv value and larger than the first Cv value.

[Claim 5]

The refrigerator of any one of claims 2 to 4, wherein the controller is configured to control the selecting unit to periodically select the second stage and the third stage alternately when the target Cv value is not larger than the first Cv value and is larger than the second Cv value.

[Claim 6]

The refrigerator of any one of claims 2 to 5, wherein

the selecting unit is further configured to select a fourth stage in which the refrigerant flows to none of the first capillary tube and the second capillary tube, and

the controller is configured to control the selecting unit to periodically select the third stage and the fourth stage alternately when the target Cv value is not larger than the second Cv value.

[Claim 7]

The refrigerator of any one of claims 2 to 6, wherein, when the first stage and the second stage are alternately selected periodically, or when the second stage and

the third stage are alternately selected periodically, the controller is configured to change a duration of each stage on a basis of the target Cv value.

[Claim 8]

The refrigerator of any one of claims 2 to 7, wherein, when the first stage and the second stage are alternately selected periodically, or when the second stage and the third stage are alternately selected periodically, the controller is configured to set a duration of each stage in one period so that an average of the Cv values in the one period is equal to the target Cv value.

[Claim 9]

The refrigerator of any one of claims 1 to 8, wherein the plurality of capillary tubes are different in at least one of diameter and length.

[Claim 10]

The refrigerator of any one of claims 1 to 9, further comprising a soundproof material disposed around the selecting unit.

[Claim 11]

A method of controlling a flow rate of refrigerant for a refrigerator,

the refrigerator comprising:

a storage compartment;

a refrigerant circuit in which a compressor, a radiator, a plurality of capillary tubes having different Cv values, a selecting unit configured to select at least one of the plurality of capillary tubes, and a cooler are connected to each other via pipes to circulate refrigerant, the refrigerant flowing through the at least one of the plurality of capillary tubes; and

a controller,

the method comprising:

outputting a first sensor value on a basis of detection of an evaporating temperature of the refrigerant or an evaporating pressure of the refrigerant;

outputting a second sensor value on a basis of detection of at least one of a condensing temperature of the refrigerant and a condensing pressure of the refrigerant; and

controlling the selecting unit on a basis of a flow rate of the refrigerant based on a rotational frequency of the compressor, the first sensor value, and the second sensor value,

the plurality of capillary tubes including a first capillary tube having a first Cv value, and a second capillary tube having a second Cv value smaller than the first Cv value,

the controlling the selecting unit including

periodically selecting a first stage in which the refrigerant flows to both of the first capillary tube and the second capillary tube, and a second stage in which the refrigerant flows only to the first capillary tube alternately, or

periodically selecting the second stage, and a third stage in which the refrigerant flows only to the second capillary tube alternately.