REFRIGERATOR AND REFRIGERATION SYSTEM

FIELD

[0001]

Embodiments of the present invention relate to a refrigerator and a refrigeration system.

BACKGROUND

[0002]

A compressor of a refrigerator generates heat when a refrigerant is compressed in the compressor. When the temperature of the compressor is excessively high, materials used in the compressor or the oil (lubricating oil) in the compressor are degraded. Therefore, cooling of the compressor has been studied.

Hereinafter, a system that forms a refrigerating cycle circuit by itself is referred to as a refrigeration system, and in the refrigeration system, for example, a system not including an evaporator is referred to as a refrigerator (semi-complete product).

[0003]

As a technology for cooling a compressor, for example, an injection control method in which a liquid-phase refrigerant continuously flows into a cylinder of the compressor little by little is known. When the liquid-phase refrigerant in the cylinder evaporates, the compressor is deprived of evaporation heat and the compressor is cooled.

On the other hand, a gas-phase refrigerant is compressed, for example, by rotating a roller in the cylinder. To lubricate the roller with respect to the cylinder, oil is supplied into the cylinder.

[0004]

Conventionally, as a refrigerator connected to a store showcase or the like having an evaporator, a refrigerator in which R404A is filled (sealed) as a refrigerant is known. The global warming potential (GWP) of R404A is relatively high at 3,920. For this reason, refrigerants which are low in GWP and are alternatives to R404A have been studied. A mixed refrigerant containing HFC-32, HFC-125, HFC-134a, and HFO-1234yf (hereinafter also referred to as mixed refrigerants containing HFC-32 and the like) has been studied as one of alternative refrigerants. GWP values are 675 for HFC-32, 3,500 for HFC-125, 1,430 for HFC-134a, and 4 for HFO-1234yf.

[0005]

However, mixed refrigerants containing HFC-32 and the like tend to have a higher temperature in a refrigerant discharged from a compressor as compared to R404A. Therefore, in order to cool the compressor, it is necessary to increase an amount of the refrigerant used for the injection operation. When the amount of the refrigerant used for the injection operation increases, the oil in the cylinder may be washed away (flow out) from the inside of the cylinder to the outside. The cylinder and the roller may have poor lubrication and there is concern that the inside of the cylinder may be damaged.

PRIOR ART DOCUMENTS

[0006]

[PATENT DOCUMENT 1] Japanese Unexamined Patent Application, First Publication No. 2012-526182

[PATENT DOCUMENT 2] Japanese Unexamined Patent Application, First Publication No. 2012-509390

SUMMARY

PROBLEMS TO BE SOLVED BY THE INVENTION

[0007]

The present invention is directed to providing a refrigerator which suppresses abnormal heat generation of a compressor, suppresses poor lubrication of the compressor, and suppresses degradation of reliability, and a refrigeration system including the refrigerator.

MEANS FOR SOLVING THE PROBLEMS

[0008]

According to one embodiment, a refrigerator of an embodiment includes a compressor, a condenser, a main pipe, a bypass pipe, an opening/closing mechanism, a temperature measurer, and a controller. The main pipe includes a first end and a second end. The main pipe connects the first end, the compressor, the condenser, and the second end together in sequence. The bypass pipe connects a portion of the main pipe between the condenser and the second end to the compressor. The opening/closing mechanism is provided in the bypass pipe. The opening/closing mechanism switches between an open state in which a refrigerant flows through the bypass pipe and a closed state in which the refrigerant does not flow through the bypass pipe, and throttles the refrigerant in the open state. The temperature measurer measures a temperature of the refrigerant discharged from the compressor. The controller is configured to control the opening/closing mechanism. The main pipe is connected to the evaporator and a throttle device to constitute a refrigerating cycle circuit. At least R404A or mixed refrigerants containing HFC-32, HFC-125, HFC-134a, and HFO-1234yf are able to be used for the refrigerant. When mixed refrigerants containing HFC-32, HFC-125, HFC-134a, and HFO-1234yf are used as the refrigerant, the controller is configured to set the opening/closing mechanism to the open state when a measurement result of the temperature measurer reaches a first temperature and is configured to set the opening/closing mechanism to the closed state when a measurement result reaches a

second temperature which is lower than the first temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a schematic configuration view showing a refrigeration system of an embodiment.

FIG. 2 is a cross-sectional view of a main portion of a compressor of the refrigeration system of the embodiment.

FIG. 3 is a view showing changes in temperature and opening degree of an electronic expansion valve when the refrigeration system of the embodiment using R448A is operated.

FIG. 4 is a view showing changes in temperature and opening degree of an electronic expansion valve when the refrigeration system of the embodiment using R404A is operated.

DETAILED DESCRIPTION

[0010]

Hereinafter, a refrigerator and a refrigeration system of an embodiment will be described with reference to the drawings.

[0011]

As shown in FIG. 1, a refrigeration system 1 includes a refrigerator 2 of the present embodiment, an evaporator 11 and an expansion valve (throttle device) 12 which are connected to a main pipe 22 of the refrigerator 2 to be described below, and a refrigerant R filled into the refrigerator 2, the evaporator 11, the expansion valve 12, and the like.

In this example, the refrigerator 2 is connected to a showcase 10 in a store (not shown). The showcase 10 includes the evaporator 11 and the expansion valve 12 which are described above, and a connection pipe 13 which connects the evaporator 11 and the expansion valve 12 in sequence.

As the evaporator 11, for example, a fin tube type heat exchanger or the like can be used.

As the expansion valve 12, an electronic expansion valve (PMV: Pulse Motor Valve) or an automatic expansion valve can be used.

Further, in the present embodiment, a case in which an automatic expansion valve is used as the throttle device will be described.

[0012]

The expansion valve 12 can switch between an open state in which the refrigerant R flows through the connection pipe 13 and a closed state in which the refrigerant does not flow through the connection pipe 13. In addition, the expansion valve 12 can adjust a flow rate of the refrigerant R flowing through the connection pipe 13 by adjusting an opening degree between the open state and the closed state.

The evaporator 11 is provided at a position in the connection pipe 13 closer to a first end 22a of the main pipe 22 to be described below than the expansion valve 12. A blower for sending air to the evaporator 11 may be disposed at a position facing the evaporator 11.

[0013]

The refrigerator 2 includes a compressor 20, a condenser 21, the main pipe 22 which connects the compressor 20 and the condenser 21 in sequence, a bypass pipe 23 connected to the main pipe 22, an electronic expansion valve (opening/closing mechanism) 24 provided in the bypass pipe 23, a temperature sensor (temperature

measurer) 25 which measures the temperature of the refrigerant R discharged from the compressor 20, and a controller 26 which is configured to control the compressor 20, the electronic expansion valve 24, and the like.

The main pipe 22 includes the first end 22a and a second end 22b. The main pipe 22 connects the first end 22a, the compressor 20, the condenser 21, and the second end 22b in sequence such that they start communicating.

[0014]

In this example, the compressor 20 includes a rotary type compression mechanism 20a as shown in FIG. 2. That is, when a motor 20c (see FIG. 1) is driven, cylindrical rollers 31 rotate respectively in a pair of cylinders 30 provided in a case 29. The rollers 31 are slide-rotatably disposed to follow eccentric rotation of a crank of a rotating shaft 31a. The rollers 31 rotate and move from a position shown in the drawing to a position P1, for example. A space between the pair of cylinders 30 is partitioned by a partition plate 32. The bypass pipe 23 passes through the inside of the partition plate 32 and is connected to the inside of the cylinders 30. The refrigerant R supplied into the bypass pipe 23 is supplied into each cylinder 30 via a through hole 23a.

In the present embodiment, the compressor 20 is a so-called twin rotary compressor, but types of the compressor are not limited thereto. The compressor may be a rotary compressor having one roller, and may also be a reciprocating type, a scroll type, or the like.

[0015]

As the temperature sensor 25, for example, sensors of a contact type, a non-contact type, or the like can be used. In the present embodiment, the temperature sensor 25 is attached to a discharge port 20b through which the refrigerant R is discharged from the compressor 20 as shown in FIG. 1. The temperature sensor 25

measures a temperature of the refrigerant R discharged from the compressor 20, more specifically, a temperature of the discharge port 20b through which the discharged refrigerant R passes.

At a position of the compressor 20 close to the first end 22a of the main pipe 22, a suction cup 35, which is a relatively small-sized gas-liquid separator, is provided.

[0016]

As the condenser 21, a condenser configured similar to the evaporator 11 can be used. At a position facing the condenser 21, a blower 34 for sending air to the condenser 21 is disposed.

Connection portions 22c and 22d which are packed valves or the like for connecting to and disconnecting from the connection pipe 13 of the showcase 10 are provided at the first end 22a and the second end 22b of the main pipe 22.

At a portion of the main pipe 22 closer to the second end 22b than the condenser 21, a receiver tank 36 for temporarily storing the refrigerant R is provided.

The bypass pipe 23 connects a portion of the main pipe 22 between the receiver tank 36 (condenser 21) and the second end 22b to the inside of the cylinder 30 of the compressor 20.

[0017]

The electronic expansion valve 24 switches between an open state in which the refrigerant R flows through the bypass pipe 23 and a closed state in which the refrigerant R does not flow through the bypass pipe 23. The electronic expansion valve 24 throttles a flow of the refrigerant R in the open state. When the electronic expansion valve 24 is set to the open state, the refrigerant R flows into the cylinder 30 through the bypass pipe 23. An injection operation in which the compressor 20 is cooled is performed using the refrigerant R. The electronic expansion valve 24 is a bypass valve that switches the

bypass pipe 23 between the open state and the closed state.

At positions of the bypass pipe 23 closer to the receiver tank 36 than the electronic expansion valve 24, in the order of becoming closer to the receiver tank 36, a strainer 38 for removing foreign matter in the refrigerant R and a high pressure switch 39 for emergency stop of the compressor 20 are provided.

When the pressure of the refrigerant R in the bypass pipe 23 becomes greater than a predetermined threshold value, the high pressure switch 39 transmits a signal to the controller 26. On the basis of this signal, the controller 26 stops an operation of the compressor 20.

[0018]

A strainer 41, a pressure sensor 42, and a check valve 43 are provided in the order of becoming closer to the first end 22a at portions of the main pipe 22 between the first end 22a and the compressor 20.

The pressure sensor 42 transmits a measurement result of a pressure of the refrigerant R in the main pipe 22 to the controller 26. Also, the controller 26 may stop the operation of the compressor 20 on the basis of the signal transmitted from the pressure sensor 42.

The check valve 43 allows flow of the refrigerant R from the first end 22a toward the second end 22b in the main pipe 22, but restricts flow of the refrigerant R from the second end 22b toward the first end 22a.

[0019]

A second bypass pipe 45 is provided to connect a portion between the check valve 43 and the suction cup 35, and a portion between the compressor 20 and the condenser 21 in the main pipe 22. A solenoid valve 46 is attached to the second bypass pipe 45. The solenoid valve 46 switches between an open state in which the refrigerant

R flows through the second bypass pipe 45 and a closed state in which the refrigerant R does not flow through the second bypass pipe 45.

The electronic expansion valve 24, the motor 20c, the temperature sensor 25, the blower 34, the high pressure switch 39, the pressure sensor 42, and the solenoid valve 46 are individually connected to the controller 26.

A temperature of the refrigerant R discharged from the compressor 20 measured by the temperature sensor 25, and a pressure of the refrigerant R in the main pipe 22 measured by the pressure sensor 42 are transmitted to the controller 26 at predetermined intervals.

[0020]

Although not shown, the controller 26 is configured with an arithmetic circuit, a memory, and the like, and performs control on the basis of a control program, for example. A first temperature which is, for example, about 80ºC, a second temperature which is about 70ºC, and the like which are used for control of the electronic expansion valve 24 are stored in the memory of the controller 26.

The arithmetic circuit of the controller 26 controls the expansion valve 12, the electronic expansion valve 24, the motor 20c of the compressor 20, the temperature sensor 25, the blower 34, the high pressure switch 39, the pressure sensor 42, and the solenoid valve 46 on the basis of the measurement results of the temperature and pressure of the refrigerant R. On the basis of the first and second temperatures, an open/closed state of the electronic expansion valve 24 is switched.

The main pipe 22 is connected to the evaporator 11 and the expansion valve 12 via the connection pipe 13 by the connection portions 22c and 22d, thereby constituting a refrigerating cycle circuit 3.

[0021]

As the refrigerant R of the present embodiment, mixed refrigerants (mixed refrigerants containing HFC-32 and the like) containing HFC-32, HFC-125, HFC-134a, and HFO-1234yf can be used.

As one mixed refrigerant, R448A containing 26 wt% HFC-32, 26 wt% HFC-125, 21 wt% HFC-134a, 20 wt% HFO-1234yf, and 7 wt% HFO-1234ze can be used.

HFC-32 has a chemical name of difluoromethane and a chemical formula of CH_2F_2. HFC-125 has a chemical name of pentafluoroethane and a chemical formula of CHF_2CF_3. HFC-134a has a chemical name of 1,1,1,2-tetrafluoroethane and a chemical formula of $C_2H_2F_4$. HFO-1234yf has a chemical name of 2,3,3,3-tetrafluoro-1-propene and a chemical formula of $CF_3CF=CH_2$. Further, HFO-1234ze has a chemical name of (E)-1,3,3,3-tetrafluoropropene (trans-1,3,3,3-tetrafluoropropene). The chemical formula of HFO-1234ze is trans–$CF_3CH=CHF$, $C_3H_2F_4$, and the global warming potential (GWP) thereof is 7.

[0022]

As another mixed refrigerant, R449A containing 24 wt% HFC-32, 25 wt% HFC-125, 26 wt% HFC-134a, and 25 wt% HFO-1234yf can be used.

Further, R404A filled into the refrigeration system 1 contains 44 wt% HFC-125, 4 wt% HFC-134a, and 52 wt% HFC-143a.

The refrigerant R is filled into the compressor 20, the condenser 21, the main pipe 22, the evaporator 11, the expansion valve 12, the connection pipe 13, and the like.

[0023]

Next, operations of the refrigerator 2 and the refrigeration system 1 of the present embodiment having the configuration as above will be described.

An operator connects the connection portions 22c and 22d of the main pipe 22 of the refrigerator 2 in which the refrigerant R is not filled into the connection pipe 13 of

the showcase 10 in the store. At this time, the electronic expansion valve 24 and the solenoid valve 46 are in a closed state. The expansion valve 12 is also in a closed state.

A vacuum pump (not shown) is connected to the main pipe 22 of the refrigeration system 1 to evacuate the inside of the main pipe 22, the connection pipe 13, and the like.

After the evacuation is completed, the connection to the vacuum pump is removed, and the inside of the main pipe 22, the inside of the connection pipe 13, and the like are filled with the refrigerant R which is, for example, R448A. The solenoid valve 46 is set to an open state so that pressures at the condenser 21 and the evaporator 11 of the refrigerating cycle circuit 3 are equalized.

With the processes as above, the refrigeration system 1 is configured with the evaporator 11, the expansion valve 12, and the connection pipe 13 of the showcase 10, and the refrigerator 2.

[0024]

When the operator activates the refrigeration system 1, the controller 26 drives the compressor 20. The refrigerant R that has passed through the suction cup 35 is suctioned into the cylinder 30 of the compressor 20. The blower 34 is driven to send air to the condenser 21. The temperature of the refrigerant R discharged from the compressor 20 measured by the temperature sensor 25, and the pressure of the refrigerant R in the main pipe 22 measured by the pressure sensor 42 are transmitted to the controller 26 at predetermined intervals.

Since pressures at the condenser 21 and the evaporator 11 of the refrigerating cycle circuit 3 are equalized, it is easy to start driving of the compressor 20. The controller 26 is configured to set the solenoid valve 46 to the closed state after elapse of a predetermined time from the start of driving the compressor 20.

[0025]

The refrigerant R which is compressed by rotation of the roller 31 in the cylinder 30 and is at high temperature and high pressure is discharged from the discharge port 20b of the compressor 20. At this time, the change in temperature of the discharge port 20b with respect to time is indicated by a line L1 in FIG. 3. The change in temperature of the refrigerant R with respect to time at an intermediate position between an inlet and outlet of the refrigerant R in the condenser 21 is indicated by a line L2. The change in temperature of the refrigerant R with respect to time at an intermediate position between an inlet and outlet of the refrigerant R in the evaporator 11 is indicated by a line L3. The open/closed state of the electronic expansion valve 24 is indicated by a line L4.

For the lines L1, L2, and L3 indicating temperatures, the vertical axis on the left side is used. For the line L4 indicating an opening degree of the electronic expansion valve 24, the vertical axis on the right side is used.

The electronic expansion valve 24 is controlled by switching to either a closed state or an open state in which the opening degree is fixed. Further, the electronic expansion valve 24 may be controlled so that the opening degree changes gradually or the opening degree changes in stages.

In FIG. 3, a change in temperature for 30 minutes and a change in opening degree of the electronic expansion valve 24 when an operation of the refrigeration system 1 is stabilized are shown.

[0026]

A certain amount of oil is supplied into the cylinder 30 from a lubricating oil path provided in the rotating shaft 31a. The refrigerant R discharged from the compressor 20 flows through the condenser 21 through the main pipe 22. At this time, the refrigerant R is cooled by the blower 34.

The refrigerant R flowing out from the inside of the condenser 21 passes through the receiver tank 36, and then rapidly expands due to the expansion valve 12. A pressure of the refrigerant R that has passed through the expansion valve 12 decreases, and a temperature thereof decreases due to an enthalpy change when being deprived of evaporation heat, or the like.

The refrigerant R that has passed through the expansion valve 12 flows into the evaporator 11, and is heated and evaporated by the air sent from the blower.

On the other hand, the air sent from the blower is deprived of heat and thus the showcase 10 is cooled.

[0027]

The refrigerant R exiting from the inside of the evaporator 11 flows inside the connection pipe 13 and inside the main pipe 22 in sequence. The refrigerant R passes through the suction cup 35 and then is suctioned into the cylinder 30 of the compressor 20. By adjusting the opening degree of the expansion valve 12, the flow rate of the refrigerant R flowing in the refrigeration system 1 is adjusted.

At this time, since the electronic expansion valve 24 is in the closed state and the injection operation is not performed, the oil in the cylinder 30 cannot be easily washed away from the inside of the cylinder 30 to the outside.

As time passes, the temperature of the refrigerant R discharged from the compressor 20 increases. When a measurement result of the temperature sensor 25 reaches a first temperature t1 which is, for example, about 80ºC, the controller 26 is configured to set the electronic expansion valve 24 to the open state. Specifically, as shown in FIG. 3, the temperature of the refrigerant R of the discharge port 20b indicated by the line L1 increases with the elapse of time. At a time T1 when the temperature of the discharged refrigerant R has reached the first temperature t1, the controller 26

changes the closed state of the electronic expansion valve 24 to the open state.

[0028]

Thereby, the refrigerant R flows into the cylinder 30 of the compressor 20 through the bypass pipe 23, and the compressor 20 is cooled by the evaporation heat of the refrigerant R. Some of the oil in the cylinder 30 is washed away by the refrigerant R that has flowed in from the injection operation.

As time passes, the temperature of the refrigerant R of the discharge port 20b decreases. When a measurement result of the temperature sensor 25 reaches a second temperature t2 which is, for example, about 70ºC, the controller 26 is configured to set the electronic expansion valve 24 to the closed state. The second temperature t2 is lower than the first temperature t1.

Since the injection operation is not performed, the oil in the cylinder 30 cannot be easily washed away.

[0029]

Since the injection operation is not performed, the temperature of the refrigerant R discharged from the compressor 20 increases with the elapse of time. In this manner, a period $\Delta T1$ configured from one interval of the electronic expansion valve 24 in the closed state and one interval thereof in the open state is repeated.

As described above, the refrigerant R continues to flow intermittently in the refrigeration system 1.

[0030]

In a refrigeration system of another embodiment, a result of operating a refrigeration system using R404A instead of R448A as the refrigerant R of the refrigeration system 1 is shown in FIG. 4. The change in temperature of the discharge port 20b at this time is indicated by a line L11 in FIG. 4. The change in temperature of

the refrigerant R of the condenser 21 is indicated by a line L12. The time of the temperature of the refrigerant R of the evaporator 11 is indicated by a line L13. The open/closed state of the electronic expansion valve 24 is indicated by a line L14. As in FIG. 3, FIG. 4 also shows a change in temperature for 30 minutes and a change in opening degree of the electronic expansion valve 24.

The first temperature t1 and the second temperature t2 respectively have the same temperature when R448A is used as the refrigerant R and when R404A is used as the refrigerant R. That is, the first temperature t1 when R448A is used as the refrigerant R and the first temperature t1 when R404A is used as the refrigerant R are equal. Similarly, the second temperature t2 when R448A is used as the refrigerant R and the second temperature t2 when R404A is used as the refrigerant R are equal.

[0031]

When R404A is used as the refrigerant R, a period ΔT2 configured from one interval of the electronic expansion valve 24 in the closed state and one interval thereof in the open state is repeated. As described above, also in the refrigeration system using R404A as the refrigerant R, the electronic expansion valve 24 is intermittently opened and closed, and the refrigerant R can continue to flow intermittently.

Since R404A tends to have a lower temperature of the refrigerant discharged from the compressor 20 as compared to R448A, the cycle ΔT2 is longer as compared to the cycle ΔT1. In other words, the electronic expansion valve 24 is more frequently opened and closed when R448A is used as the refrigerant R than when R404A is used.

[0032]

As described above, according to the refrigerator 2 and the refrigeration system 1 of the present embodiment, R448A is used as the refrigerant R and the open/closed state of the electronic expansion valve 24 is switched. When the electronic expansion

valve 24 is in the open state, the compressor 20 is cooled by the injection operation, and when the electronic expansion valve 24 is in the closed state, the oil in the cylinder 30 cannot be easily washed away. Therefore, it is possible to prevent the oil from being washed away from the compressor 20 while lowering the temperature of the refrigerant R discharged from the compressor 20.

[0033]

Since R448A tends to have a higher temperature in the refrigerant R discharged from the compressor 20 (an amount of heat transport of the refrigerant R increases) as compared to R404A, it is necessary to increase an amount of the refrigerant R used for the injection operation when R448A is used. Therefore, when R448A is used as the refrigerant R as compared with the case in which R404A is used as the refrigerant R, it is thought that it is preferable to lower both the first temperature t1 and the second temperature t2 for switching the open/closed state of the electronic expansion valve 24.

However, in the present embodiment, the first temperature t1 and the second temperature t2 are respectively have fixed temperatures when R448A is used as the refrigerant R and when R404A is used as the refrigerant R. A cycle of opening and closing the electronic expansion valve 24 in the case in which R448A is used as the refrigerant R of the present embodiment is shorter than in the case in which R404A is used as the refrigerant R. That is, a frequency at which the electronic expansion valve 24 is opened and closed is high.

[0034]

When R448A is used as the refrigerant R, a period during which the oil in the cylinder 30 is washed away by the injection operation with the electronic expansion valve 24 in an open state is shorter in one cycle $\Delta T1$ than in the case in which R404A is used as the refrigerator R. Thereby, the amount of the refrigerant R used for the

injection operation in one period ΔT1 is reduced, the oil cannot be easily washed away, and abrasion between the cylinder 30 and the roller 31 can be reduced. Therefore, even when R448A of which the refrigerant temperature is easy to rise is used, reliability of the refrigeration system 1 can be enhanced.

[0035]

In the above-described embodiment, the case in which R448A is used as the refrigerant R has been described, but the refrigerant R that can be used in the refrigeration system 1 is not limited to R448A. Refrigerants R that can be used in the refrigeration system 1 include R449A or mixed refrigerants containing HFC-32 and the like.

The opening/closing mechanism is assumed to be the electronic expansion valve 24. However, the opening/closing mechanism may be configured with a two-way valve for switching between an open state in which the refrigerant R flows through the bypass pipe 23 and a closed state in which the refrigerant R does not flow through the bypass pipe 23, and a capillary tube connected in series to the two-way valve.

[0036]

According to at least one embodiment described above, by having the electronic expansion valve 24 and the controller 26, it is possible to prevent the oil from being washed away from the compressor 20 while lowering the temperature of the refrigerant R discharged from the compressor 20.

[0037]

In the embodiment described above, the case in which an automatic expansion valve is used as the expansion valve 12 has been described, but an electronic expansion valve may be used, and in this case, operation control of the electronic expansion valve may be performed by the controller 26 provided in the refrigerator 2. In addition, a

central controller or the like for collectively controlling the entire refrigeration system 1 including the refrigerator 2 and the showcase 10 in the store may be separately provided to perform control of the entire system.

[0038]

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

CLAIMS

1. A refrigerator comprising:

a compressor;

a condenser;

a main pipe which includes a first end and a second end, and connects the first end, the compressor, the condenser, and the second end together in sequence;

a bypass pipe which connects a portion of the main pipe between the condenser and the second end to the compressor;

an opening/closing mechanism provided in the bypass pipe, configured to switch between an open state in which a refrigerant flows through the bypass pipe and a closed state in which the refrigerant does not flow through the bypass pipe, and configured to throttle the refrigerant in the open state;

a temperature measurer which measures a temperature of the refrigerant discharged from the compressor; and

a controller which is configured to control the opening/closing mechanism, wherein

the main pipe is connected to an evaporator and a throttle device to constitute a refrigerating cycle circuit,

at least R404A or mixed refrigerants containing HFC-32, HFC-125, HFC-134a, and HFO-1234yf are able to be used for the refrigerant, and

when mixed refrigerants containing HFC-32, HFC-125, HFC-134a, and HFO-1234yf are used as the refrigerant, the controller is configured to set the opening/closing mechanism to the open state when a measurement result of the temperature measurer reaches a first temperature and is configured to set the

opening/closing mechanism to the closed state when a measurement result of reaches a second temperature which is lower than the first temperature.

2. The refrigerator according to claim 1, wherein:

when R404A is used as the refrigerant, the controller is configured to set the opening/closing mechanism to the open state when a measurement result of the temperature measurer reaches the first temperature and is configured to set the opening/closing mechanism to the closed state when a measurement result reaches the second temperature which is lower than the first temperature, and

the first temperature and the second temperature have the same temperature when mixed refrigerants are used as the refrigerant and when R404A is used as the refrigerant.

3. The refrigerator according to claim 1 or 2, wherein the mixed refrigerant contains 26 wt% HFC-32, 26 wt% HFC-125, 21 wt% HFC-134a, 20 wt% HFO-1234yf, and 7 wt% HFO-1234ze.

4. The refrigerator according to claim 1 or 2, wherein the mixed refrigerant contains 24 wt% HFC-32, 25 wt% HFC-125, 26 wt% HFC-134a, and 25 wt% HFO-1234yf.

5. A refrigeration system comprising:

a refrigerator according to any one of claims 1 to 4;

the evaporator and the throttle device which are connected to the main pipe; and

a refrigerant filled into the compressor, the condenser, the main pipe, the

evaporator, and the throttle device.