



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.11.2017 Bulletin 2017/48

(51) Int Cl.:
F25B 1/00 ^(2006.01) **F25B 1/04** ^(2006.01)
F25B 43/02 ^(2006.01)

(21) Application number: **16755055.7**

(86) International application number:
PCT/JP2016/050793

(22) Date of filing: **13.01.2016**

(87) International publication number:
WO 2016/136305 (01.09.2016 Gazette 2016/35)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **MIYAMOTO, Yoshiaki**
Tokyo 108-8215 (JP)
• **KIMATA, Yoshiyuki**
Tokyo 108-8215 (JP)
• **TAKASU, Yogo**
Tokyo 108-8215 (JP)
• **TAKAHASHI, Kazuki**
Tokyo 108-8215 (JP)

(30) Priority: **26.02.2015 JP 2015036885**

(74) Representative: **Intès, Didier Gérard André et al**
Cabinet Beau de Loménie
158 rue de l'Université
75340 Paris Cedex 07 (FR)

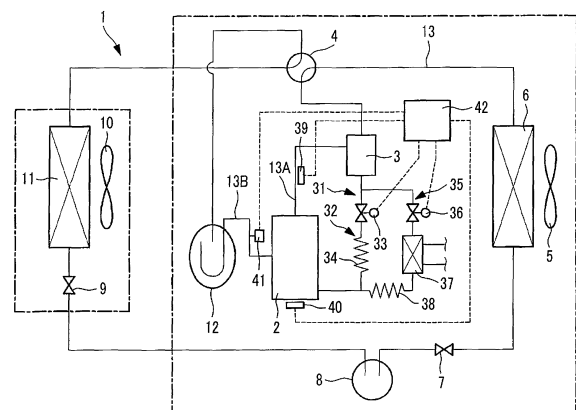
(71) Applicant: **Mitsubishi Heavy Industries Thermal Systems, Ltd.**
Tokyo 108-8215 (JP)

(54) **OIL RETURN CIRCUIT AND OIL RETURN METHOD FOR REFRIGERATING CYCLE**

(57) The purpose of the present invention is to make it possible to minimize any increase in oil temperature within a compressor and to ensure a permissible operating range and conditions comparable to those for R410A refrigerant, even when a R32 refrigerant having a high discharge gas temperature is used, as well as to minimize any increase in the oil circulation rate and the effects on the refrigerating cycle capacity and performance. The present invention is provided with a refrigerating cycle (1) equipped with a low-pressure housing-type compressor (2) and filled with R32 refrigerant, an oil separator (3) provided to the discharge circuit (13A) of the compressor, and an oil return circuit (31) for returning the oil separated by the oil separator to an oil reservoir inside the housing of the compressor. The oil return circuit is a parallel circuit comprising a direct circuit (32) for direct return of oil to the oil reservoir in the housing, and a cooling circuit (35) for return of oil having been cooled by an oil cooler (37), and is provided with an oil temperature control unit (42) for detecting at least one parameter among the discharge temperature of the refrigerant, and the oil temperature or oil viscosity within the compressor, and when the parameter exceeds a threshold value, switching the oil return circuit from the direct circuit to the cooling circuit, and returning the oil once the oil temperature is brought to a prescribed tem-

perature or lower.

FIG. 1



Description

Citation List

Technical Field

Patent Literature

[0001] The present invention relates to an oil return circuit and an oil return method for a refrigerating cycle using a R32 refrigerant or a R32 refrigerant-rich mixed refrigerant (hereinafter, referred to simply as a R32 refrigerant), in which a global warming potential (hereinafter, referred to as GWP) is low.

5 **[0007]**

[PTL 1] Japanese Unexamined Patent Application Publication No. 2014-85104

[PTL 2] Japanese Unexamined Patent Application Publication No. 6-337171

[PTL 3] Japanese Unexamined Patent Application Publication No. 11-83204

[PTL 4] Japanese Unexamined Patent Application Publication No. 2005-214515

[PTL 5] Japanese Unexamined Patent Application Publication No. 2006-170570

Background Art

[0002] A R32 refrigerant has an ozone depletion potential (ODP) of zero and a low GWP of about 1/3 of that of a R410A refrigerant, and therefore, the R32 refrigerant can contribute to a reduction of environmental burden and is used as an alternative refrigerant for the R410A refrigerant. However, in the R32 refrigerant, a discharge gas temperature rises by a temperature in a range of about 10 to 20°C, as compared with the R410A refrigerant, and the discharge gas temperature tends to rise as a pressure ratio between suction pressure and discharge pressure increases, and thus an oil temperature in a compressor rises due to return oil from an oil separator. When associated with this, oil viscosity decreases, and therefore, it is necessary to limit an allowable operating range or condition, compared to the R410A refrigerant.

Summary of Invention

20 Technical Problem

[0008] However, in the refrigerating cycle of PTL 1 described above, the inside of the housing of the compressor must have not only a high-pressure atmosphere but also an oil separating function, and the compressor must have a direct suction and direct discharge structure. Furthermore, each of the first bypass flow path and the second bypass flow path must be formed by high-pressure gas piping having a relatively large diameter, and thus a compressor structure and a piping structure around it become complicated and expensive, and there is a problem such as being unable to be applied to a refrigerating cycle using a low-pressure housing type compressor.

[0003] PTL 1 discloses a refrigerating cycle in which an oil separator is provided in a discharge circuit of a compressor, and during the cooling operation, a refrigerant containing oil discharged from the compressor is directly cooled from the oil separator through a first bypass flow path by a cooler and then returned into a housing of the compressor, where the oil is separated, and only the refrigerant is circulated to a condenser through a second bypass flow path, whereby an oil temperature rise in the compressor is suppressed.

35

[0009] On the other hand, in a refrigerating cycle using a low-pressure housing type compressor in which the inside of a housing is under a low-pressure atmosphere, only the oil separated by an oil separator can be returned to the compressor side through an oil return circuit, as shown in PTL 2 to PTL 5. At this time, by returning the oil to a suction circuit of the compressor, it is possible to cool the oil with a low-pressure refrigerant gas and return it to the compressor with an oil temperature lowered. However, in this case, the oil and the refrigerant gas are remixed, and therefore, they must be separated again in the compressor, and thus there is a problem such as an oil rise due to a decrease in oil separation efficiency, that is, an increase in oil circulation rate.

[0004] During the heating operation, the refrigerant and the oil are separated from each other by the oil separator, the refrigerant is circulated to the condenser to be provided for heating, and the oil is cooled through the first bypass flow path and the cooler and then returned to the compressor, whereby a rise in oil temperature and a decrease in heating capacity are suppressed.

45

[0005] On the other hand, in a refrigerating cycle using the R410A refrigerant or the like, conventionally, an oil separator is provided in a discharge circuit of a compressor, oil contained in a refrigerant gas is separated by the oil separator, and a refrigerant is then circulated to a condenser, and such refrigerating cycles are disclosed in PTL 2 to PTL 5.

50

[0006] In these refrigerating cycles, the separated oil is returned to the compressor or a suction circuit of the compressor by an oil return circuit, alternatively, an oil cooler is provided in the oil return circuit and the oil is cooled as necessary and then returned to the compressor side.

55

[0010] Further, a technique has been also proposed in which an oil cooler is provided in an oil return circuit such that the oil cooled there is directly returned to an oil reservoir of a compressor housing. However, in this case, the oil is constantly cooled by the oil cooler, and therefore, in a case where a refrigerant is used as a cold source in the oil cooler, there is a problem such as the capacity or the performance of a refrigerating cycle being affected.

[0011] The present invention has been made in view of such circumstances and has an object to provide an oil return circuit and an oil return method for a refrigerating

cycle in which even in a case of using a R32 refrigerant in which a discharge gas temperature becomes high, it is possible to suppress a rise in oil temperature in a compressor and secure an allowable operating range or condition equivalent to that for a R410A refrigerant, and it is possible to suppress an increase in oil circulation rate or the influence on the capacity or the performance of the refrigerating cycle.

Solution to Problem

[0012] In order to solve the above-described problems, an oil return circuit and an oil return method for a refrigerating cycle according to the present invention adopt the following means.

[0013] That is, an oil return circuit for a refrigerating cycle according to the present invention includes: a refrigerating cycle which is provided with a compressor in which an inside of a housing having an oil reservoir has a low-pressure atmosphere, and has a R32 refrigerant or a R32-rich mixed refrigerant filled in the cycle; an oil separator provided in a discharge circuit from the compressor; and an oil return circuit in which the separated oil by the oil separator is depressurized and the oil returns to the oil reservoir in the housing, in which the oil return circuit is a parallel circuit composed of a direct circuit which directly returns oil from the oil separator to the oil reservoir and a cooling circuit which cools oil by an oil cooler and returns the cooled oil to the oil reservoir, and is provided with an oil temperature control unit which detects at least one of a discharge temperature of the refrigerant and an oil temperature or oil viscosity in the compressor, and when it exceeds a threshold value set in advance, switches the oil return circuit from the direct circuit to the cooling circuit to cool return oil to a temperature less than or equal to a predetermined temperature and return the oil to the oil reservoir.

[0014] According to the present invention, even in a case where a discharge gas temperature rises due to using the

[0015] R32 refrigerant or the R32-rich mixed refrigerant, at least one of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor is detected, and when it exceeds the threshold value set in advance, the oil return circuit is switched from the direct circuit to the cooling circuit so as to cool oil to a temperature less than or equal to a predetermined temperature by the oil cooler and return the cooled oil to the oil reservoir in the housing of the compressor, whereby it is possible to limit an oil temperature rise in the compressor to a value less than or equal to a specified value. Therefore, it is possible to suppress a rise in oil temperature in the compressor and secure an allowable operating range or condition equivalent to that for the R410A refrigerant. Further, the oil separated by the oil separator can be directly returned to the oil reservoir in the housing, and therefore, it is possible to prevent re-mixing with the refrigerant gas and suppress an increase in oil circulation

rate in order to hold the returned oil in the oil reservoir, and it is only necessary to cool oil only when necessary, and thus it is possible to minimize the influence on the capacity or the performance of the refrigerating cycle.

[0016] Further, in an oil return circuit for a refrigerating cycle according to the present invention, in the oil return circuit for a refrigerating cycle described above, the compressor is a low-pressure housing type scroll compressor of either a hermetic type or an open type, and the oil reservoir in the housing is filled with PVE oil, POE oil, PAG oil, or a mixed oil containing them as its main component.

[0017] According to the present invention, a low-pressure housing type scroll compressor of a hermetic type or an open type for a R410A refrigerant configured to suction a low-pressure refrigerant gas from the refrigerating cycle side into the housing, suction and compress the refrigerant, and discharge it to a discharge chamber can be applied as it is.

[0018] In this case, PVE oil (polyvinyl ether-based oil), POE oil (polyol ester-based oil), PAG oil (polyalkylene glycol-based oil), or mixed oil thereof adapted to the refrigerant is filled, whereby it is possible to configure a refrigerating cycle using the R32 refrigerant or the R32-rich mixed refrigerant and operate the refrigerating cycle while securing an allowable operating range or condition equivalent to that for the R410A refrigerant.

[0019] Therefore, it is possible to reliably eliminate poor lubrication or the like caused by a decrease in oil viscosity due to an oil temperature rise in the compressor. Further, in a case where the compressor is an open type compressor, effects such as being able to suppress generation of oil sludge associated with a rise in the temperature of a sliding part at a shaft seal portion due to a mechanical seal or a lip seal and prevent refrigerant leakage are exhibited.

[0020] Further, an oil return method for a refrigerating cycle according to the present invention is an oil return method for a refrigerating cycle in which an oil separator is provided in a discharge circuit of the compressor of the refrigerating cycle which is provided with a low-pressure housing type compressor and has a R32 refrigerant or a R32-rich mixed refrigerant filled in the cycle, and oil separated by the oil separator is returned to an oil reservoir in a housing of the compressor through an oil return circuit, the oil return method including: detecting at least one of a discharge temperature of the refrigerant and an oil temperature or oil viscosity in the compressor; and limiting an oil temperature rise in the compressor to a value less than or equal to a specified value, when a detection value exceeds a threshold value set in advance, by cooling return oil to a temperature less than or equal to a predetermined temperature by an oil cooler provided in the oil return circuit and returning the oil to the oil reservoir.

[0021] According to the present invention, even in a case where a discharge gas temperature rises due to using the R32 refrigerant or the R32-rich mixed refrigerant

ant, at least one of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor is detected, and when the detection value exceeds a threshold value set in advance, return oil is cooled to a temperature less than or equal to a predetermined temperature by the oil cooler provided in the oil return circuit and returned to the oil reservoir in the housing of the compressor, whereby it is possible to limit an oil temperature rise in the compressor to a value less than or equal to a specified value.

[0022] Therefore, it is possible to suppress a rise in oil temperature in the compressor and secure an allowable operating range or condition equivalent to that for the R410A refrigerant. Further, the oil separated by the oil separator can be directly returned to the oil reservoir in the housing, and therefore, it is possible to prevent re-mixing with the refrigerant gas and suppress an increase in oil circulation rate in order to hold the returned oil in the oil reservoir, and it is only necessary to cool oil only when necessary, and thus it is possible to minimize the influence on the capacity or the performance of the refrigerating cycle.

[0023] Further, in an oil return method for a refrigerating cycle according to the present invention, in the oil return method for a refrigerating cycle described above, the oil return circuit is a parallel circuit composed of a direct circuit which directly returns oil from the oil separator to the oil reservoir and a cooling circuit which cools oil by the oil cooler and returns the cooled oil to the oil reservoir, and when at least one of detection values of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor exceeds the threshold value, the oil return circuit is switched from the direct circuit to the cooling circuit to cool return oil to a temperature less than or equal to a predetermined temperature by the oil cooler and return the oil to the oil reservoir.

[0024] According to the present invention, when at least one of the detection values of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor is less than or equal to the threshold value, oil is directly returned from the oil separator to the oil reservoir through the direct circuit, and when the detection value exceeds the threshold value, oil can be cooled to a temperature less than or equal to a predetermined temperature by the oil cooler of the cooling circuit and then returned to the oil reservoir. Therefore, it is possible to reliably limit an oil temperature rise in the compressor to a value less than or equal to a specified value, and it is only necessary to cool oil by the oil cooler only when necessary, and thus it is possible to minimize the influence on the capacity or the performance of the refrigerating cycle.

Advantageous Effects of Invention

[0025] According to the oil return circuit and an oil return method for a refrigerating cycle according to the

present invention, even in a case where the discharge gas temperature rises due to using the R32 refrigerant or the R32-rich mixed refrigerant, at least one of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor is detected, and when it exceeds the threshold value set in advance, the oil return circuit is switched from the direct circuit to the cooling circuit so as to cool oil to a temperature less than or equal to a predetermined temperature by the oil cooler and return the cooled oil to the oil reservoir in the housing of the compressor, whereby it is possible to limit an oil temperature rise in the compressor to a value less than or equal to a specified value.

[0026] For this reason, it is possible to suppress a rise in oil temperature in the compressor and secure an allowable operating range or condition equivalent to that for the R410A refrigerant. Further, the oil separated by the oil separator can be directly returned to the oil reservoir in the compressor, and therefore, it is possible to prevent re-mixing with the refrigerant gas and suppress an increase in oil circulation rate in order to hold the returned oil in the oil reservoir, and it is only necessary to cool oil only when necessary, and thus it is possible to minimize the influence on the capacity or the performance of the refrigerating cycle.

Brief Description of Drawings

[0027]

Fig. 1 is a refrigerant circuit diagram which includes an oil return circuit for a refrigerating cycle according to an embodiment of the present invention.

Fig. 2 is a longitudinal sectional view of a low-pressure housing type compressor which is applied to the refrigerating cycle.

Description of Embodiments

[0028] Hereinafter, an embodiment of the present invention will be described using Figs. 1 and 2.

[0029] In Fig. 1, a refrigerant circuit diagram which includes an oil return circuit for a refrigerating cycle according to an embodiment of the present invention is shown, and in Fig. 2, a longitudinal sectional view of a low-pressure housing type compressor which is applied to the refrigerating cycle is shown.

[0030] A refrigerating cycle 1 here is a refrigerating cycle filled with a R32 refrigerant or a R32-rich mixed refrigerant (hereinafter, referred to simply as a R32 refrigerant) as a refrigerant and is a heat pump cycle which is provided with a four-way switching valve 4 and allows cooling and heating to be performed by switching a refrigerant circulation direction. However, it may be a single cycle for refrigeration or a heat pump.

[0031] The refrigerating cycle 1 is configured by a closed cycle refrigerant cycle in which a low-pressure housing type compressor 2, an oil separator 3 provided

in a discharge circuit 13A of the compressor 2, the four-way switching valve 4 which switches a refrigerant circulation direction, an outdoor-side heat exchanger 6 to which a blower 5 is attached, an electronic expansion valve for heating 7, a receiver 8, an electronic expansion valve for cooling 9, an indoor-side heat exchanger 11 to which a blower 10 is attached, and an accumulator 12 provided in a suction circuit 13B of the compressor 2 are sequentially connected by refrigerant piping 13.

[0032] The compressor 2 is a hermetic type electric scroll compressor 2, as shown in Fig. 2. The hermetic type electric scroll compressor 2 is a compressor which is provided with a longitudinally elongated cylinder-shaped housing 14 having a hermetic structure configuring an outer shell and in which a scroll compression mechanism 15 is incorporated into an upper portion of the inside of the housing 14. The scroll compression mechanism 15 is provided with a pair of fixed scroll 16 and orbiting scroll 17, as well known, and is incorporated through a bearing member 18 fixedly installed in the housing 14. A configuration is made in which a high-pressure refrigerant gas compressed by the scroll compression mechanism 15 is discharged into a discharge chamber 19 and sent to the discharge circuit 13A on the refrigerating cycle 1 side through a discharge pipe 20.

[0033] In the housing 14, a motor 21 composed of a stator 22 and a rotor 23 is fixedly installed below the scroll compression mechanism 15. A driving shaft 24 is integrally joined to the rotor 23 of the motor 21, and a crankpin provided at an upper end of the driving shaft 24 is connected to the back surface of the orbiting scroll 17 of the scroll compression mechanism 15 through a drive bush and a slewing bearing, whereby the scroll compression mechanism 15 can be driven.

[0034] The upper end side of the driving shaft 24 is supported by the bearing member 18, and a lower end portion is supported by a bearing member 25 installed at a lower portion in the housing 14. An oil supply pump 26 is provided between the lower end portion of the driving shaft 24 and the bearing member 25, and thus a configuration is made in which lubricating oil (oil) filled in an oil reservoir 27 of an inner bottom portion of the housing 14 can be supplied to a sliding part of the scroll compression mechanism 15 through an oil supply hole 28 provided in the driving shaft 24. The hermetic type electric scroll compressor 2 provided with such an oil supply mechanism is well known.

[0035] The compressor 2 does not need to be the hermetic type electric scroll compressor 2 as described above and may be an open type scroll compressor having an oil reservoir in a housing, or other types of compressor other than a scroll compressor.

[0036] The lubricating oil (oil) which is filled in the oil reservoir 27 in the housing 14 is PVE oil (polyvinyl ether-based oil), POE oil (polyol ester-based oil), or PAG oil (polyalkylene glycol-based oil) having adaptability to the R32 refrigerant, or mixed oil containing them as its main component, and oil having viscosity in a range of about

20 to 150 cP at 40°C is used.

[0037] In this embodiment, a suction pipe 29 is provided at an outer peripheral portion of the housing 14 so as to be open to a space portion between the motor 21 and the scroll compression mechanism 15, and the compressor 2 is connected to the suction circuit 13B on the refrigerating cycle 1 side through the suction pipe 29. In this way, the hermetic type electric scroll compressor 2 is regarded as the low-pressure housing type compressor 2 in which the inside of the housing 14 has a low-pressure atmosphere.

[0038] An oil return circuit 31 for returning oil separated by the oil separator 3 provided in the discharge circuit 13A on the refrigerating cycle 1 side to the oil reservoir 27 on the compressor 2 side is connected to the housing 14 of the hermetic type electric scroll compressor 2, as shown in Fig. 1. The oil return circuit 31 is configured by a parallel circuit composed of a direct circuit 32 which directly returns oil separated by the oil separator 3 to the oil reservoir 27 through an electromagnetic valve 33 and a capillary tube 34 for pressure reduction and flow rate adjustment, and a cooling circuit 35 which is connected in parallel to the direct circuit 32 and returns the oil from the oil separator 3 to the oil reservoir 27 through an electromagnetic valve 36, an oil cooler 37, and a capillary tube 38 for pressure reduction and flow rate adjustment.

[0039] As a cold source for cooling oil by the oil cooler 37, a part of a high-pressure liquid refrigerant circulating in the refrigerant circuit of the refrigerating cycle 1, a gas-liquid two-phase refrigerant decompressed by the expansion valve, a low-pressure gas refrigerant, or the like is used, and it is possible to adopt a refrigerant cooling type which performs cooling by heat exchange with a refrigerant, an air cooling type which performs cooling by air cooling using the blower 5 attached to the outdoor-side heat exchanger 6, or the like.

[0040] The oil return circuit 31 has a configuration in which in order to limit an oil temperature rise in the housing 14 of the compressor 2 to a value less than or equal to a specified value, at least one of a discharge temperature of the refrigerant and an oil temperature or oil viscosity in the compressor 2 is detected, and when a detection value exceeds a threshold value set in advance, the oil return circuit 31 is switched from the direct circuit 32 to the cooling circuit 35, so that return oil can be cooled to a temperature less than or equal to a predetermined temperature and then returned to the oil reservoir 27.

[0041] That is, the oil return circuit 31 has a configuration in which it is provided with an oil temperature control unit 42 which controls opening and closing of the electromagnetic valves 33 and 36 so as to switch the oil return circuit 31 from the direct circuit 32 to the cooling circuit 35, when at least one of a detection value of a discharge temperature sensor 39 provided in the discharge circuit 13A of the refrigerating cycle 1, a detection value of an oil temperature sensor 40 provided at the bottom portion of the housing of the compressor 2, the oil viscosity calculated based on the detection values of a low-pressure

pressure sensor 41 provided in the suction circuit 13B of the refrigerating cycle 1 and the oil temperature sensor 40, and the like exceeds a threshold value set in advance, and the return oil from the oil separator 3 is cooled to a temperature less than or equal to a predetermined temperature by the oil cooler 37 and then returned to the oil reservoir 27.

[0042] With the configuration described above, according to this embodiment, the following operation and effects are exhibited.

[0043] In the refrigerating cycle 1 described above, a cooling operation can be performed by circulating a high-temperature and high-pressure refrigerant gas discharged from the compressor 2 to the outdoor-side heat exchanger 6 side by the four-way switching valve 4 and causing the outdoor-side heat exchanger 6 to function as a condenser and the indoor-side heat exchanger 11 to function as an evaporator, and a heating operation can be performed by circulating the high-temperature and high-pressure refrigerant gas to the indoor-side heat exchanger 11 side by the four-way switching valve 4 and causing the indoor-side heat exchanger 11 to function as a condenser and the outdoor-side heat exchanger 6 to function as an evaporator.

[0044] During this time, oil contained in the discharged refrigerant gas from the compressor 2 is separated by the oil separator 3 provided in the discharge circuit 13A and returned to the oil reservoir 27 of the hermetic type electric scroll compressor 2 which is a low-pressure housing type through the oil return circuit 31.

[0045] The oil return circuit 31 is a parallel circuit composed of the direct circuit 32 which directly returns oil to the oil reservoir 27 and the cooling circuit 35 which cools oil by the oil cooler 37 and then returns it to the oil reservoir 27. For this reason, in a case where the discharge temperature of the refrigerant which is discharged from the compressor 2 rises and there is a possibility that the oil temperature in the compressor 2 may exceed a threshold value set in advance, it is detected and the oil return circuit 31 is switched from the direct circuit 32 to the cooling circuit 35, so that the return oil can be cooled to a temperature less than or equal to a predetermined temperature by the oil cooler 37 and then returned to the oil reservoir 27.

[0046] That is, the oil temperature control unit 42 detects at least one of the discharge temperature of the refrigerant which is discharged from the compressor 2 and the oil temperature or the oil viscosity in the compressor 2, on the basis of the detection values of the discharge temperature sensor 39, the oil temperature sensor 40, and the low-pressure pressure sensor 41, and functions, when it exceeds the threshold value set in advance, so as to limit an oil temperature rise in the compressor 2 to a value less than or equal to a specified value by closing the electromagnetic valve 33 from the open state and opening the electromagnetic valve 36 from the closed state, thereby switching the oil return circuit 31 from the direct circuit 32 to the cooling circuit

35 to cool the return oil to a temperature less than or equal to a predetermined temperature and returning the return oil to the oil reservoir 27.

[0047] Here, setting examples of the threshold value will be described. In a case where a combination of a refrigerant and refrigerating machine oil is R410A/PVE oil A or R32/PVE oil B, for example, when HP/LP is equal to 3.8/1.8 [MPa] and SH is equal to 10 [deg],

- (1) the discharge temperature of the refrigerant is 85°C in the R410A and 100°C in the R32, and therefore, the threshold value is set to 90°C, for example.
- (2) The oil temperature in the compressor is 70°C in the R410A and 85°C in the R32, and therefore, the threshold value is set to 75°C, for example.
- (3) The oil viscosity is 8 mm²/s in the R410A/PVE oil A and 6 mm²/s in the R32/PVE oil B, and therefore, the threshold value is set to 7.5 mm²/s, for example.

[0048] As described above, the threshold values of the discharge temperature of the refrigerant, the oil temperature in the compressor, and the oil viscosity are set, and when the respective detection values exceed the threshold values, by performing control through the oil temperature control unit 42 so as to switch the oil return circuit 31 from the direct circuit 32 to the cooling circuit 35 to cool the return oil by the oil cooler 37 such that the temperature is lowered by approximately 15 deg and then return the return oil to the oil reservoir 27, it is possible to reduce the oil temperature to the same temperature as in the case of the R410A refrigerant and make the oil viscosity approximately equivalent to that of the R410A refrigerant, and thus it is possible to secure an allowable operating range or condition equivalent to that for the R410A refrigerant.

[0049] It is known that the viscosity of oil depends on solubility in a refrigerant, which is determined according to pressure and a temperature, and it is possible to grasp the viscosity of oil by measuring a temperature and pressure with the oil temperature sensor 40 and the low-pressure pressure sensor 41, as described above, and determining solubility from a pressure/solubility characteristic diagram or the like using the temperature as a parameter.

[0050] As described above, even if there is a case where the discharge gas temperature of the refrigerant which is discharged from the compressor 2 rises due to using the R32 refrigerant instead of the R410A refrigerant, at least one of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor 2 is detected, and when it exceeds a threshold value set in advance, the oil return circuit 31 is switched from the direct circuit 32 which directly returns oil from the oil separator 3 to the oil reservoir 27 of the compressor 2 to the side of the cooling circuit 35 which cools oil by the oil cooler 37 and then returns the oil to the oil reservoir 27, and thus the oil is cooled to a temperature less than or equal to a predetermined temper-

ature by the oil cooler 37 and then returned to the oil reservoir 27 in the housing 14 of the compressor 2, whereby it is possible to limit an oil temperature rise in the compressor 2 to a value less than or equal to a specified value.

[0051] Therefore, it is possible to suppress a rise in the oil temperature in the compressor 2 and secure an allowable operating range or condition equivalent to that for the R410A refrigerant. Further, the oil separated by the oil separator 3 can be directly returned to the oil reservoir 27 in the housing 14 of the compressor 2, and therefore, it is possible to prevent re-mixing with a refrigerant gas and suppress an increase in oil circulation rate in order to hold the returned oil in the oil reservoir, and it is only necessary to cool oil only when necessary, and thus it is possible to minimize the influence on the capacity or the performance of the refrigerating cycle 1.

[0052] The compressor 2 is the low-pressure housing type scroll compressor 2 of either a hermetic type or an open type, and the oil reservoir 27 in the housing 14 is filled with any oil of PVE oil, POE oil, and PAG oil, or mixed oil containing them as its main component. For this reason, the low-pressure housing type scroll compressor 2 of a hermetic type or an open type for the R410A refrigerant configured to suction a low-pressure refrigerant gas from the refrigerating cycle 1 side into the housing 14, suction and compress the refrigerant, and discharge it to the discharge chamber 19 is applied as it is, and PVE oil, POE oil, PAG oil, or mixed oil thereof adapted to the refrigerant is filled, whereby it is possible to configure the refrigerating cycle 1 using the R32 refrigerant and operate the refrigerating cycle 1 while securing an allowable operating range or condition equivalent to that for the R410A refrigerant.

[0053] In this way, it is possible to reliably eliminate a concern such as poor lubrication caused by a decrease in oil viscosity due to an oil temperature rise in the compressor 2. In particular, in a case where the compressor 2 is an open type compressor, it is also possible to expect effects such as being able to suppress generation of oil sludge associated with a rise in the temperature of a sliding part at a shaft seal portion by a mechanical seal or a lip seal and prevent refrigerant leakage.

[0054] Further, the oil return circuit 31 is a parallel circuit composed of the direct circuit 32 which directly returns the oil separated by the oil separator 3 from the oil separator 3 to the oil reservoir 27 and the cooling circuit 35 which cools the oil by the oil cooler 37 and then returns it to the oil reservoir 27, and when at least one of the detection values of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor 2 exceeds a threshold value, the oil return circuit 31 is switched from the direct circuit 32 to the cooling circuit 35.

[0055] In this way, the return oil is cooled to a temperature less than or equal to a predetermined temperature by the oil cooler 37 and then returned to the oil reservoir 27, and therefore, it is possible to reliably limit an oil tem-

perature rise in the compressor 2 to a value less than or equal to a specified value, and it is only necessary to cool the oil by the oil cooler 37 only when necessary, and thus it is possible to minimize the influence on the capacity or the performance of the refrigerating cycle 1.

[0056] The present invention is not limited to the invention according to the above-described embodiment and can be appropriately modified within a scope which does not depart from the gist of the invention. For example, in the above-described embodiment, the discharge temperature sensor 39, the oil temperature sensor 40, and the low-pressure pressure sensor 41 are provided to detect the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor 2. However, a configuration may be made such that sensors which are provided for the operation control of the refrigerating cycle 1 are applied to these sensors and the electromagnetic valves 33 and 36 are controlled by using the detection values thereof, and thus it is not necessary to newly install sensors.

Reference Signs List

[0057]

- 1: refrigerating cycle
- 2: compressor (hermetic type electric scroll compressor)
- 3: oil separator
- 13A: discharge circuit
- 14: housing
- 27: oil reservoir
- 31: oil return circuit
- 32: direct circuit
- 33, 36: electromagnetic valve
- 34, 38: capillary tube
- 35: cooling circuit
- 37: oil cooler
- 39: discharge temperature sensor
- 40: oil temperature sensor
- 41: low-pressure pressure sensor
- 42: oil temperature control unit

Claims

1. An oil return circuit for a refrigerating cycle comprising:
 - a refrigerating cycle which is provided with a compressor in which an inside of a housing having an oil reservoir has a low-pressure atmosphere, and has a R32 refrigerant or a R32-rich mixed refrigerant filled in the cycle;
 - an oil separator provided in a discharge circuit from the compressor; and
 - an oil return circuit in which the separated oil by the oil separator are depressurized and the oil

returns to the oil reservoir in the housing, wherein the oil return circuit is a parallel circuit composed of a direct circuit which directly returns oil from the oil separator to the oil reservoir and a cooling circuit which cools oil by an oil cooler and returns the cooled oil to the oil reservoir, and is provided with an oil temperature control unit which detects at least one of a discharge temperature of the refrigerant and an oil temperature or oil viscosity in the compressor, and when it exceeds a threshold value set in advance, switches the oil return circuit from the direct circuit to the cooling circuit to cool return oil to a temperature less than or equal to a predetermined temperature and return the oil to the oil reservoir.

2. The oil return circuit for a refrigerating cycle according to Claim 1, wherein the compressor is a low-pressure housing type scroll compressor of either a hermetic type or an open type, and the oil reservoir in the housing is filled with PVE oil, POE oil, PAG oil, or a mixed oil containing them as its main component.
3. An oil return method for a refrigerating cycle in which an oil separator is provided in a discharge circuit of the compressor of the refrigerating cycle which is provided with a low-pressure housing type compressor and has a R32 refrigerant or a R32-rich mixed refrigerant filled in the cycle, and oil separated by the oil separator is returned to an oil reservoir in a housing of the compressor through an oil return circuit, the oil return method comprising:

detecting at least one of a discharge temperature of the refrigerant and an oil temperature or oil viscosity in the compressor; and limiting an oil temperature rise in the compressor to a value less than or equal to a specified value, when the detection value exceeds a threshold value set in advance, by cooling return oil to a temperature less than or equal to a predetermined temperature by an oil cooler provided in the oil return circuit and returning the oil to the oil reservoir.

4. The oil return method for a refrigerating cycle according to Claim 3, wherein the oil return circuit is a parallel circuit composed of a direct circuit which directly returns oil from the oil separator to the oil reservoir and a cooling circuit which cools oil by the oil cooler and returns the cooled oil to the oil reservoir, and when at least one of detection values of the discharge temperature of the refrigerant and the oil temperature or the oil viscosity in the compressor ex-

ceeds the threshold value, the oil return circuit is switched from the direct circuit to the cooling circuit to cool return oil to a temperature less than or equal to a predetermined temperature by the oil cooler and return the oil to the oil reservoir.

Amended claims under Art. 19.1 PCT

1. (Amended) An oil return circuit for a refrigerating cycle comprising:

a refrigerating cycle which is provided with a compressor in which an inside of a housing having an oil reservoir has a low-pressure atmosphere, and has a R32 refrigerant or a R32-rich mixed refrigerant filled in the cycle; an oil separator provided in a discharge circuit from the compressor; and an oil return circuit in which the separated oil by the oil separator is depressurized and the oil returns to the oil reservoir in the housing, wherein the oil return circuit is a parallel circuit composed of a direct circuit which directly returns oil from the oil separator to the oil reservoir and a cooling circuit which cools oil by an oil cooler and returns the cooled oil to the oil reservoir, and is provided with an oil temperature control unit which calculates oil viscosity in the compressor on the basis of detection values of pressure of the refrigerant in a suction circuit of the refrigerating cycle and an oil temperature in the oil reservoir, and when it exceeds a threshold value set in advance, switches the oil return circuit from the direct circuit to the cooling circuit to cool return oil to a temperature less than or equal to a predetermined temperature and return the oil to the oil reservoir.

2. The oil return circuit for a refrigerating cycle according to Claim 1, wherein the compressor is a low-pressure housing type scroll compressor of either a hermetic type or an open type, and the oil reservoir in the housing is filled with PVE oil, POE oil, PAG oil, or a mixed oil containing them as its main component.
3. (Amended) An oil return method for a refrigerating cycle in which an oil separator is provided in a discharge circuit of the compressor of the refrigerating cycle which is provided with a low-pressure housing type compressor and has a R32 refrigerant or a R32-rich mixed refrigerant filled in the cycle, and oil separated by the oil separator is returned to an oil reservoir in a housing of the compressor through an oil return circuit, the oil return method comprising:

calculating oil viscosity in the compressor on the basis of detection values of pressure of the refrigerant in a suction circuit of the refrigerating cycle and an oil temperature in the oil reservoir, and

5

limiting an oil temperature rise in the compressor to a value less than or equal to a specified value, when the calculated value exceeds a threshold value set in advance, by cooling return oil to a temperature less than or equal to a predetermined temperature by an oil cooler provided in the oil return circuit and returning the oil to the oil reservoir.

10

4. (Amended) The oil return method for a refrigerating cycle according to Claim 3, wherein the oil return circuit is a parallel circuit composed of a direct circuit which directly returns the oil from the oil separator to the oil reservoir and a cooling circuit which cools the oil by the oil cooler and returns the cooled oil to the oil reservoir, and
- when a calculated value of the oil viscosity in the compressor exceeds the threshold value, the oil return circuit is switched from the direct circuit to the cooling circuit to cool return oil to a temperature less than or equal to a predetermined temperature by the oil cooler and return the oil to the oil reservoir.

15

20

25

30

35

40

45

50

55

FIG. 1

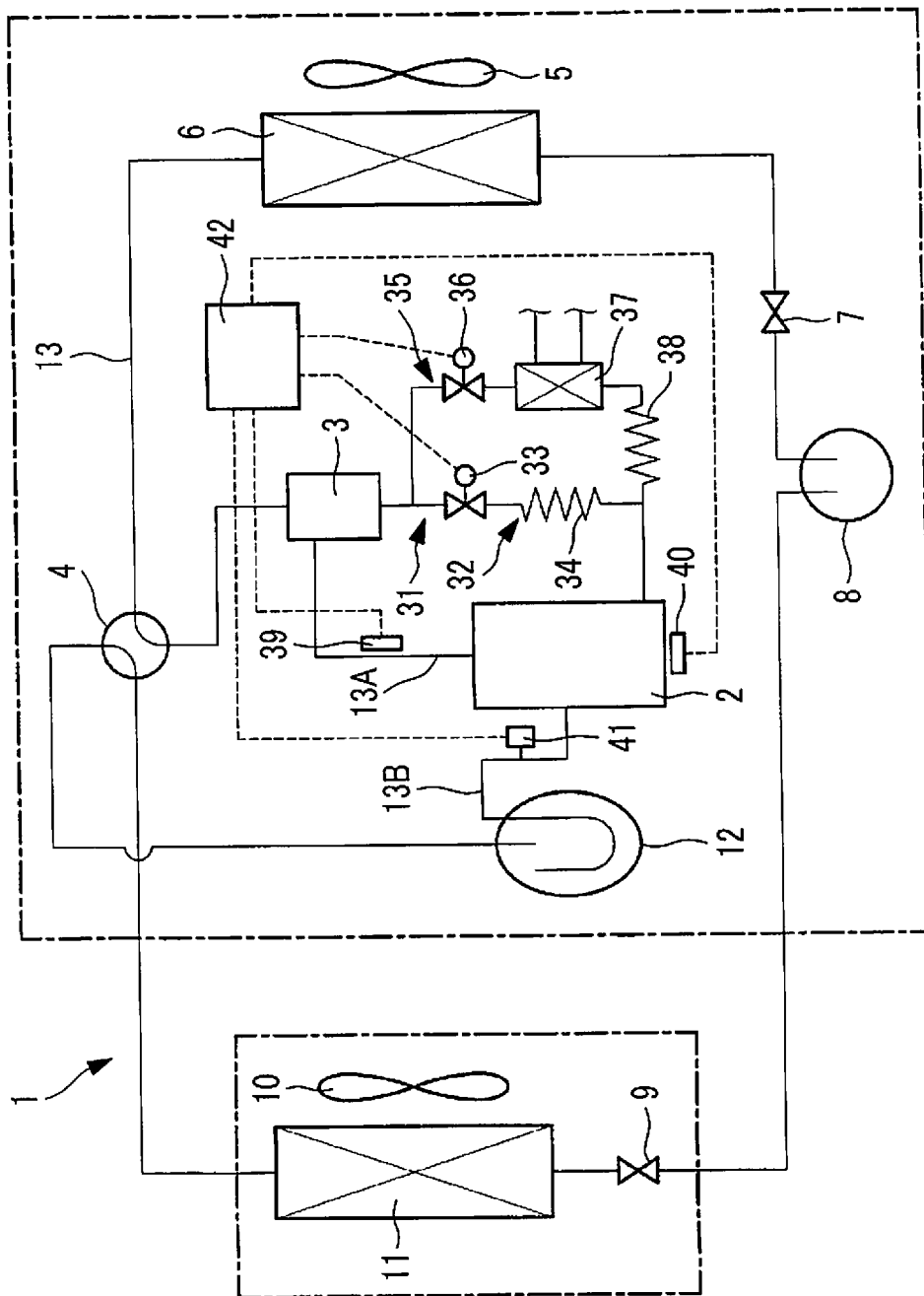
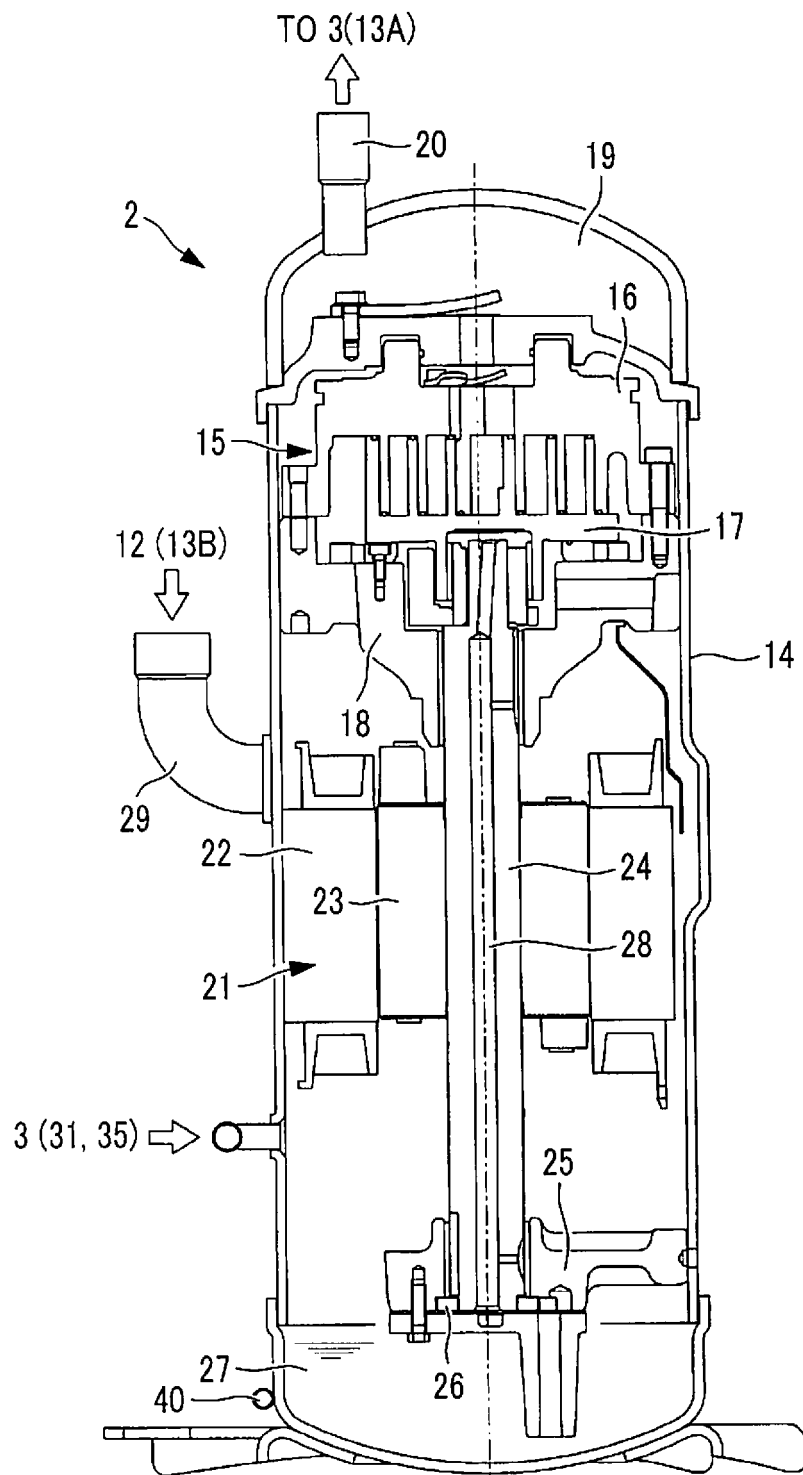


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/050793

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00(2006.01)i, F25B1/04(2006.01)i, F25B43/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B1/00, F25B1/04, F25B43/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016

Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-133209 A (Sanyo Electric Co., Ltd.), 07 July 2011 (07.07.2011), paragraphs [0005] to [0006], [0018] to [0026], [0097] to [0107]; fig. 1 to 2 & US 2011/0154840 A1 paragraphs [0006], [0071] to [0079], [0161] to [0172]; fig. 1 to 2 & EP 2339265 A2 & CN 102109239 A & KR 10-2011-0074711 A	1-4
Y	JP 2005-83704 A (Mitsubishi Electric Corp.), 31 March 2005 (31.03.2005), claims 10, 12; paragraphs [0008] to [0018]; fig. 1 to 2 (Family: none)	1-4

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
29 March 2016 (29.03.16)Date of mailing of the international search report
05 April 2016 (05.04.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/050793

C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2012-247134 A (Sanyo Electric Co., Ltd.), 13 December 2012 (13.12.2012), paragraphs [0045], [0047], [0056], [0074]; fig. 1 (Family: none)	1-4
Y	JP 7-19634 A (Mitsubishi Electric Corp.), 20 January 1995 (20.01.1995), paragraphs [0025], [0030], [0034]; fig. 1 to 2 (Family: none)	1-4
Y	JP 2006-170500 A (Mitsubishi Heavy Industries, Ltd.), 29 June 2006 (29.06.2006), paragraphs [0003], [0012] to [00021]; fig. 1 to 4 (Family: none)	1-4
A	JP 2011-196594 A (Panasonic Corp.), 06 October 2011 (06.10.2011), entire text; all drawings (Family: none)	1-4
A	JP 2009-79820 A (Sanyo Electric Co., Ltd.), 16 April 2009 (16.04.2009), paragraphs [0037] to [0040]; fig. 4 to 5 (Family: none)	1-4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2014085104 A [0007]
- JP 6337171 A [0007]
- JP 11083204 A [0007]
- JP 2005214515 A [0007]
- JP 2006170570 A [0007]