(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 160 102 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
08.01.2025 Bulletin 2025/02

(21) Application number: **21800140.2**

(22) Date of filing: **08.02.2021**

(51) International Patent Classification (IPC):
F24F 11/32 *(2018.01)* ***F24F 11/64*** *(2018.01)*
F24F 11/70 *(2018.01)* ***F25B 31/00*** *(2006.01)*
F25B 5/02 *(2006.01)* ***F25B 49/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F25B 31/004; F25B 49/02; F25B 5/02;
F25B 2500/16; F25B 2600/2513

(86) International application number:
PCT/CN2021/075909

(87) International publication number:
WO 2021/223481 (11.11.2021 Gazette 2021/45)

(54) **OIL RETURN CONTROL METHOD FOR MULTI-SPLIT SYSTEM**

ÖLRÜCKLAUFSTEUERVERFAHREN FÜR MULTISPLITSYSTEM

PROCÉDÉ DE COMMANDE DE RETOUR D’HUILE POUR SYSTÈME À DIVISIONS MULTIPLES

(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

(30) Priority: **25.05.2020 CN 202010449608**

(43) Date of publication of application:
05.04.2023 Bulletin 2023/14

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(56) References cited:
CN-A- 106 839 330
CN-A- 109 357 440
CN-A- 109 612 021
CN-A- 109 631 248
CN-A- 110 542 255
JP-A- 2011 149 659
US-A1- 2019 346 188

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Description

FIELD OF THE INVENTION

[0001] The present invention belongs to the technical field of air conditioning, and specifically provides an oil return control method for a multi-connection system.

BACKGROUND OF THE INVENTION

[0002] A multi-connection system usually consists of a plurality of indoor units and at least one outdoor unit. During the actual operation, some indoor units are in a shutdown or standby state. If an expansion valve of the shutdown or standby indoor unit is closed, a lubricating oil in connecting pipes and heat exchanger of the indoor unit cannot be circulated into the system. As the time elapses, there will be more and more lubricating oil in the indoor unit, causing the compressor to suffer severe wear due to lack of the lubricating oil or causing damage to the compressor due to overheating. In order to ensure a normal operation of the multi-connection system, oil return control is required so that the lubricating oil can be normally circulated into the system.

[0003] In traditional oil return control methods, the oil is usually returned according to a fixed cycle. During the oil return process, the expansion valve is opened by a fixed opening degree, and the system terminates the oil return after an oil return operation time is reached. Document US 2019/346188 A1 discloses an oil return control method according to the preamble of claim 1.

[0004] However, since the actual working condition of each indoor unit is different, after the oil return of the system is completed, the lubricating oil stored in some indoor units may have returned to the system long ago, but their expansion valves are still in the open state, so that a refrigerant can continue to flow in these indoor units, which will not only generate noise, but also lead to problems such as insufficient refrigerant and poor heat exchange performance of the system in normally turned-on indoor units; even worse, when the opening degree of the expansion valve is too large, there will be a liquid hammer phenomenon in the compressor. However, there may still be a large amount of lubricating oil left in some other shutdown or standby indoor units that has not yet returned to the system, and there is still a problem of insufficient lubricating oil in the compressor.

[0005] As can be seen from the above, the traditional oil return control methods have not fundamentally solved the problem of insufficient lubricating oil in the compressor, and may also cause the problem of poor overall heat exchange performance of the system due to the insufficient amount of refrigerant in the normally turned-on indoor units. That is, the traditional oil return control methods cannot give considerations to both the oil return effect and the heat exchange performance of the system.

[0006] Accordingly, there is an urgent need in the art for a new oil return control method to solve the above technical problem existing in the traditional oil return control methods.

SUMMARY OF THE INVENTION

[0007] In order to solve the above technical problem existing in the traditional oil return control methods, the present invention provides an oil return control method for a multi-connection system according to claim 1.

[0008] In the oil return control method for the multi-connection system, the multi-connection system includes a plurality of indoor units, at least one of which is not turned on, and the oil return control method includes: determining an oil storage quantity q of the indoor units; determining a system oil return time T of the multi-connection system; determining a current opening degree k of an expansion valve of one indoor unit that is not turned on according to the oil storage quantity q and the system oil return time T; comparing the current opening degree k with a maximum opening degree threshold k_{smax} and a minimum opening degree threshold k_{smin}; selectively adjusting the opening degree of the expansion valve according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T.

[0009] In a preferred technical solution of the above oil return control method, the step of "determining a current opening degree k of an expansion valve of the one indoor unit that is not turned on according to the oil storage quantity q and the system oil return time T" specifically includes calculating the current opening degree k using the following formula:

$$k = q(k_{smax} \times T_{smax})/(q_{smax} \times T);$$

where q_{smax} represents a maximum oil storage quantity threshold of the indoor unit, k_{smax} represents the maximum opening degree threshold of the expansion valve, and T_{smax} represents a maximum system oil return time threshold of the multi-connection system.

[0010] In a preferred technical solution of the above oil return control method, the step of "selectively adjusting the opening degree of the expansion valve according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T" specifically includes: determining an indoor unit oil return time t of the one indoor unit that is not turned on according to the following formula if $k<k_{smin}$:

$$t = (k \times \mathrm{T})/k_{smin};$$

adjusting the opening degree of the expansion valve to k_{smin}, and keeping the expansion valve operating at the adjusted opening degree for the time t; adjusting the opening degree of the expansion valve to zero, keeping the expansion valve operating at the adjusted opening degree for a time T-t, and then returning to the step of determining q.

[0011] In a preferred technical solution of the above oil return control method, the step of "selectively adjusting the opening degree of the expansion valve according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T" specifically includes: keeping the expansion valve operating at the current opening degree k for the system oil return time T if $k_{smin} \leq k \leq k_{smax}$, and then returning to the step of determining q.

[0012] In a preferred technical solution of the above oil return control method, the step of "selectively adjusting the opening degree of the expansion valve according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T" specifically includes: adjusting the opening degree of the expansion valve to k_{smax} if $k>k_{smax}$, keeping the expansion valve operating at the adjusted opening degree for the system oil return time T, and then returning to the step of determining q.

[0013] In a preferred technical solution of the above oil return control method, before returning to the step of determining q, the expansion valve is kept operating at the adjusted opening degree for an oil return interval time Ti.

[0014] In a preferred technical solution of the above oil return control method, the step of "keeping the expansion valve operating at the adjusted opening degree for an oil return interval time T_i" specifically includes: determining a total oil storage quantity Q of the multi-connection system according to formula (5):

$$\mathrm{Q} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{q_i};$$

where n represents the number of the indoor units, and qi represents the oil storage quantity of the i^{th} indoor unit; and

judging whether the total oil storage quantity is larger than a maximum total oil storage quantity threshold Q_{smax}; if yes, it means that the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti.

[0015] In a preferred technical solution of the above oil return control method, the step of "keeping the expansion valve operating at the adjusted opening degree for an oil return interval time T_i" specifically includes: acquiring a shutdown time t_{sp} of the indoor unit; and judging whether the shutdown time t_{sp} is larger than a maximum shutdown time threshold t_{spmax}; if yes, it means that the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti.

[0016] In a preferred technical solution of the above oil return control method, the oil storage quantity q of the indoor unit is determined according to the following formula in the oil return control method:

$$\mathrm{q} = P \times \mathrm{t}_{sp} \times (P_d - P_s) \times R_o;$$

where P represents a capacity horsepower of the indoor unit, t_{sp} represents the shutdown time of the indoor unit, P_d represents a system high pressure of the multi-connection system, P_s represents a system low pressure of the multi-connection system, and R_o represents an oil storage coefficient of the indoor unit.

[0017] In a preferred technical solution of the above oil return control method, the step of "determining a system oil return time T of the multi-connection system" includes: acquiring a maximum oil storage quantity q_{max} of the indoor unit; judging whether the maximum oil storage quantity q_{max} is larger than the maximum oil storage quantity threshold q_{smax}; if yes, determining the system oil return time T as the maximum oil return time threshold T_{smax}; otherwise, determining the system oil return time T according to the following formula:

$$\mathrm{T} = q_{max}/q_{smax} \times T_{smax}.$$

[0018] The oil return control method for the multi-connection system provided by the present invention includes: determining an oil storage quantity q of the indoor units; determining a system oil return time T of the multi-connection system; determining a current opening degree k of an expansion valve of one indoor unit that is not turned on according to the oil storage quantity q and the system oil return time T; comparing the current opening degree k with a maximum opening degree threshold k_{smax} and a minimum opening degree threshold k_{smin}; selectively adjusting the opening degree of the expansion valve according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T.

[0019] The oil return control method of the present invention can precisely control the opening degree of the expansion valve and the oil return time of each indoor unit that is not turned on, so that at the same time of providing sufficient lubricating oil to the compressor, it can also be ensured that there is sufficient amount of refrigerant in the normally turned-on indoor units, thus giving considerations to both the oil return effect and the heat exchange performance of the system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is the typical schematic structural view of a multi-connection system;
FIG. 2 is a flowchart illustrating main steps of an oil return control method for a multi-connection system of the present invention;
FIG. 3 is a flowchart illustrating detailed steps of the oil return control method for the multi-connection system of the present invention;
FIG. 4 is a flowchart illustrating detailed steps of step S200 in FIG. 3;
FIG. 5 is a flowchart illustrating detailed steps of an embodiment of step S600 in FIG. 3; and
FIG. 6 is a flowchart illustrating detailed steps of another embodiment of step S600 in FIG. 3.

DETAILED DESCRIPTION OF THE EMBODIMENT(S) OF THE INVENTION

[0021] Preferred embodiments of the present invention will be described below with reference to the accompanying drawings. It should be understood by those skilled in the art that these embodiments are only used to explain the technical principle of the present invention, and are not intended to limit the scope of protection of the present invention.

[0022] In the description of the present application, a "controller" may include hardware, software, or a combination thereof. A module may include hardware circuits, various suitable sensors, communication ports and memories, and may also include software parts, such as program codes, or a combination of software and hardware.

[0023] In order to facilitate understanding, in the following, a typical structure of a multi-connection system will be first briefly introduced with reference to FIG. 1. It should be noted that the dotted line "- - - " in FIG. 1 represents liquid pipes, and the solid line "-" in FIG. 1 represents gas pipes.

[0024] Referring to FIG. 1, a multi-connection system includes an outdoor unit and n indoor units. Each of the indoor units is connected to the outdoor unit through a gas pipe and a liquid pipe to form a refrigerant circulation system, and each of the indoor units further includes an expansion valve VE. The expansion valve VE is arranged on the liquid pipe between the outdoor unit and the corresponding indoor unit, and is configured to adjust the amount of refrigerant flowing through the indoor unit. When the refrigerant circulates between the outdoor unit and individual indoor units of the multi-connection system, the lubricating oil also circulates with the refrigerant in the system so as to lubricate and cool inner components of a compressor.

[0025] When some of the indoor units of the multi-connection system are turned on and working, some other indoor units are in a shutdown or standby state. Therefore, in order to improve readability, the indoor units in the shutdown or standby state are collectively referred to as indoor units that are not turned on herein. In order to prevent the problem of insufficient lubricating oil in the compressor caused by the accumulation of lubricating oil in the indoor units that are not turned on, generally, an opening degree of the expansion valves VE of the indoor units that are not turned on is adjusted to a fixed value within a preset period of time, so that the lubricating oil accumulated in the indoor units that are not turned on flows back into the compressor with the refrigerant, which is called an oil return control process of the multi-connection system.

[0026] However, due to the difference in the actual working conditions of various indoor units that are not turned on, after the oil return control process of the system is completed, a large amount of lubricating oil is still accumulated in some indoor units, causing the compressor to still have the problem of insufficient lubricating oil, and the lubricating oil in some other indoor units has completely flowed back into the compressor before the oil return control process is completed, but the expansion valves VE thereof still maintain a fixed opening degree. When the opening degree of the expansion valves VE is too large, a large amount of refrigerant in the system continues to flow in these indoor units, which will not only cause the liquid hammer phenomenon in the compressor, but also will cause the problems of insufficient amount of the refrigerant in the normally turned-on indoor units and poor heat exchange performance of the system.

[0027] For this reason, the present invention provides an oil return control method for a multi-connection system, which can precisely control the opening degree of the expansion valve of each indoor unit that is not turned on and the oil return time thereof, so that at the same time of providing sufficient lubricating oil to the compressor, it can also be ensured that there is sufficient amount of refrigerant in the normally turned-on indoor units, thus giving considerations to both the oil return effect and the heat exchange performance of the system.

[0028] In order to facilitate understanding the oil return control method, a main step flow of the oil return control method for the multi-connection system of the present invention will be described hereinafter with reference to FIG. 2.

[0029] Referring to FIG. 2, the main step flow of the oil return control method of the present invention includes:

Step S100: determining an oil storage quantity q of all the indoor units;
Step S200: determining a system oil return time T of the multi-connection system;
Step S300: determining a current opening degree k of an expansion valve of one indoor unit that is not turned on according to the oil storage quantity q and the system oil return time T;
Step S400: comparing the current opening degree k with a maximum opening degree threshold k_{smax} and a minimum opening degree threshold k_{smin}; and
Step S500: selectively adjusting the opening degree of the expansion valve according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T.

[0030] It should be noted that the expansion valve of the turned-on indoor unit is always in an open state before the oil is returned. In order to ensure the heat exchange effect of the multi-connection system, the opening degrees of the expansion valves of all the turned-on indoor units are normally adjusted according to a control logic before the oil return.

[0031] Further, in order to better understand the oil return control method of the present invention, a control flow of the detailed steps of the oil return control method of the present invention will described in detail below with reference to FIG. 3.

[0032] Referring to FIG. 3, a detailed step flow of the oil return control method of the present invention includes the following steps.

[0033] Step S100: determining an oil storage quantity q of all the indoor units.

[0034] Specifically, in step S 100, the oil storage quantity q of the indoor units is determined according to formula (1).

$$\mathrm{q} = P \times \mathrm{t}_{sp} \times (P_d - P_s) \times R_o \qquad (1);$$

where P represents a capacity horsepower of the indoor unit, t_{sp} represents the shutdown time of the indoor unit, P_d represents a system high pressure of the multi-connection system, P_s represents a system low pressure of the multi-connection system, and R_o represents an oil storage coefficient of the indoor unit.

[0035] It should be noted that P represents the capacity horsepower of the indoor unit. This value is a performance parameter of the indoor unit, which has been clearly set at the factory and can be acquired directly when needed, without additional calculation. t_{sp} represents the shutdown time of the indoor unit. The shutdown time t_{sp} of each indoor unit is stored in a controller of the multi-connection system, and can be read directly when needed. P_d and P_s represent the system high pressure and system low pressure of the multi-connection system respectively. These two specific values can be collected by two pressure sensors installed on the outdoor unit, and then transmitted to the controller in a wired or wireless manner for storage. Also, they can be read directly when needed.

[0036] R_o represents the oil storage coefficient of the indoor unit, and this value depends on an ambient temperature T_{ai} of the indoor unit, a saturation temperature T_{pd} corresponding to the system high pressure and a saturation temperature T_{ps} corresponding to the system low pressure under different working conditions of the system. Table 1 shows the oil storage coefficient R_o obtained under different working conditions of the indoor unit through experimental verification, and an appropriate value can be chosen from Table 1 according to the actual working conditions of the indoor unit during calculation.

Table 1

cooling		heating	
T_{ai} - T_{ps} (°C)	R_o	T_{ai} - T_{pd} (°C)	R_o
>=30	0.5	>=30	0.7
[25,30)	0.7	[25,30)	0.9
[20,25)	1.0	[20,25)	1.1
[15,20)	1.2	[15,20)	1.5
[10,15)	1.4	[10,15)	1.7
<=10	1.8	<=10	2.0

[0037] Step S200: determining a system oil return time T of the multi-connection system.

[0038] Referring to the detailed step flow chart of step S200 in FIG. 4, step S200 specifically includes:

Step S201: acquiring the maximum oil storage quantity q_{max} of the indoor unit.

[0039] The controller of the multi-connection system calculates and stores the oil storage quantity q of each indoor unit according to the aforementioned formula (1). The oil storage quantity q of the indoor unit varies according to the different working condition of the indoor unit. In step S201, the controller traverses all the oil storage quantities q of the indoor unit that have been stored, finds out the maximum oil storage quantity q_{max} therefrom and reads it directly.

[0040] Step S202: judging whether the maximum oil storage quantity q_{max} is larger than the maximum oil storage quantity threshold q_{smax}; if yes, the process proceeds to step S203; otherwise, the process proceeds to step S204.

[0041] Step S203: determining the system oil return time T as the maximum oil return time threshold T_{smax}.

[0042] Step S204: determining the system oil return time T according to formula (2):

$$\mathrm{T} = q_{max}/q_{smax} \times T_{smax} \qquad (2).$$

[0043] It should be noted that the values of the maximum oil storage quantity threshold q_{smax} and the maximum oil return time threshold T_{smax} depend on various performance parameters of the indoor unit, and they can be set by those skilled in the art according to the specific performance parameters of the indoor unit.

[0044] After the oil storage quantity q of the indoor unit and the system oil return time T are determined, with continued reference to FIG. 2, the oil return control method proceeds to step S300.

[0045] Step S300: determining the current opening degree k of the expansion valve of the indoor unit that is not turned on using the formula (3) according to the oil storage quantity q and the system oil return time T:

$$k = q(k_{smax} \times T_{smax})/(q_{smax} \times T) \qquad (3);$$

where q_{smax} represents the maximum oil storage quantity threshold of the indoor unit, k_{smax} represents the maximum opening degree threshold of the expansion valve, and T_{smax} represents the maximum system oil return time threshold of the multi-connection system. It should be noted that the values of q_{smax}, k_{smax} and a minimum opening degree threshold k_{smin} that will appear in subsequent steps depend on various performance parameters of the indoor unit, and they can be set by those skilled in the art according to the specific performance parameters of the indoor unit. The value of T_{smax} depends on the actual working parameters of the multi-connection system, and it can be set by those skilled in the art according to the actual situation.

[0046] Step S400: comparing the current opening degree k with the maximum opening degree threshold k_{smax} and a minimum opening degree threshold k_{smin}.

[0047] Step S500: selectively adjusting the opening degree of the expansion valve according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T.

[0048] In detail, step S500 specifically includes:

[0049] proceeding to step S501 if $k<k_{smin}$, and determining the indoor unit oil return time t of the indoor unit according to formula (4):

$$t = (k \times \mathrm{T})/k_{smin} \qquad (4).$$

[0050] Step S502: adjusting the opening degree of the expansion valve to k_{smin}, and keeping the expansion valve operating at the adjusted opening degree for the indoor unit oil return time t.

[0051] Step S503: adjusting the opening degree of the expansion valve to zero, and keeping the expansion valve operating at the adjusted opening degree for a time T-t; then the process returns to the step of determining q.

[0052] If $k_{smin} \le k \le k_{smax}$, the process proceeds to step S504 of keeping the expansion valve operating at the current opening degree k for the system oil return time T, and then the process returns to the step of determining q.

[0053] If $k>k_{smax}$, then the process proceeds to step S505 of adjusting the opening degree of the expansion valve to k_{smax} and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T, and then the process returns to the step of determining q.

[0054] Further, referring to FIG. 3, in order to enable the oil return control method to run periodically, before returning to the step of determining q, the oil return control method further includes:

Step S600: keeping the expansion valve operating at the adjusted opening degree for an oil return interval time Ti.

[0055] In detail, the present invention will provide two methods of judging whether the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti, and the two methods will be described in detail below with reference to FIGS. 5 and 6. It should be noted that in order to improve readability, the following two methods are distinguished by different step labels. Specifically, steps of the first method are denoted by a label S600, and steps of the second method are denoted by a label S600'.

[0056] Referring to FIG. 5, step S600 of the first method specifically includes:

Step S601: determining a total oil storage quantity Q of the multi-connection system according to formula (5):

$$Q = \sum_{i=1}^{n} q_i \qquad (5);$$

where n represents the number of the indoor units, and qi represents the oil storage quantity of the i^{th} indoor unit.
Step S602: judging whether the total oil storage quantity Q is larger than a maximum total oil storage quantity threshold Q_{smax}; if yes, the process proceeds to step S603; otherwise, the process returns to step S601.
Step S603: meaning that the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti.

[0057] Referring to FIG. 6, step S600' of the second method specifically includes:

Step S601': acquiring a shutdown time t_{sp} of the indoor unit;
Step S602': judging whether the shutdown time t_{sp} is larger than a maximum shutdown time threshold t_{spmax}; if yes, the process proceeds to step S603'; otherwise, the process returns to step S601'.
Step S603': meaning that the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti.

[0058] It can be understood that the method for judging whether the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti is not limited to the above two methods, and those skilled in the art can also use other conventional means to judge.

[0059] In addition, the present invention also provides a multi-connection air conditioning system including a controller, and the controller is configured to be capable of executing the above refrigerant flow control method. It should be noted that the basic functional components constituting the multi-connection air conditioning system and the working principle are basically the same as those in the prior art, and can be realized by those skilled in the art completely based on the prior art, so a repeated description thereof will not be given herein.

Claims

1. An oil return control method for a multi-connection system, the multi-connection system comprising a plurality of indoor units, at least one of which is not turned on, wherein the oil return control method comprises:

   determining an oil storage quantity q of all the indoor units;
   determining a system oil return time T of the multi-connection system;
   determining a current opening degree k of an expansion valve of one indoor unit that is not turned on according to the oil storage quantity q and the system oil return time T;

   characterized in that the oil return method further comprises:

   comparing the current opening degree k with a maximum opening degree threshold k_{smax} and a minimum opening degree threshold k_{smin}; and
   selectively adjusting the opening degree of the expansion valve of the one indoor unit that is not turned on according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T.

2. The oil return control method according to claim 1, wherein the step of "determining a current opening degree k of an expansion valve of the one indoor unit that is not turned on according to the oil storage quantity q and the system oil return time T" specifically comprises calculating the current opening degree k using the following formula:

   $$k = q(k_{smax} \times T_{smax})/(q_{smax} \times T);$$

   where q_{smax} represents a maximum oil storage quantity threshold of the indoor unit, k_{smax} represents the maximum opening degree threshold of the expansion valve, and T_{smax} represents a maximum system oil return time threshold of the multi-connection system.

3. The oil return control method according to claim 2, wherein the step of "selectively adjusting the opening degree of the expansion valve of the one indoor unit that is not turned on according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T" specifically comprises:

determining an indoor unit oil return time t of the one indoor unit that is not turned on according to the following formula if $k<k_{smin}$:

$$t = (k \times \mathrm{T})/k_{smin};$$

adjusting the opening degree of the expansion valve of the one indoor unit that is not turned on to k_{smin}, and keeping the expansion valve operating at the adjusted opening degree for the time t; and
adjusting the opening degree of the expansion valve to zero, keeping the expansion valve operating at the adjusted opening degree for a time T-t, and then returning to the step of determining q.

4. The oil return control method according to claim 2, wherein the step of "selectively adjusting the opening degree of the expansion valve of the one indoor unit that is not turned on according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T" specifically comprises: keeping the expansion valve operating at the current opening degree k for the system oil return time T if $k_{smin} \le k \le k_{smax}$, and then returning to the step of determining q.

5. The oil return control method according to claim 2, wherein the step of "selectively adjusting the opening degree of the expansion valve of the one indoor unit that is not turned on according to a comparison result, and keeping the expansion valve operating at the adjusted opening degree for the system oil return time T" specifically comprises: adjusting the opening degree of the expansion valve to k_{smax} if $k>k_{smax}$, keeping the expansion valve operating at the adjusted opening degree for the system oil return time T, and then returning to the step of determining q.

6. The oil return control method according to any one of claims 3 to 5, wherein before returning to the step of determining q, the expansion valve is kept operating at the adjusted opening degree for an oil return interval time Ti.

7. The oil return control method according to claim 6, wherein the oil return interval time Ti is determined through the following steps:

determining a total oil storage quantity Q of the multi-connection system according to the following formula:

$$\mathrm{Q} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{q_i};$$

judging whether the total oil storage quantity Q is larger than a maximum total oil storage quantity threshold Qsmax;
if yes, it means that the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti;
where n represents the number of the indoor units, and qi represents the oil storage quantity of the i^{th} indoor unit.

8. The oil return control method according to claim 6, wherein the oil return interval time T_i is determined through the following steps:

acquiring a shutdown time t_{sp} of the one indoor unit that is not turned on; and
judging whether the shutdown time t_{sp} is larger than or equal to a maximum shutdown time threshold t_{spmax};
if yes, it means that the expansion valve has operated at the adjusted opening degree for the oil return interval time Ti.

9. The oil return control method according to any one of claims 1 to 8, wherein the oil storage quantity q of the indoor unit is determined according to the following formula in the oil return control method:

$$\mathrm{q} = P \times \mathrm{t}_{sp} \times (P_d - P_s) \times R_o;$$

where P represents a capacity horsepower of the indoor unit, t_{sp} represents the shutdown time of the indoor unit, P_d represents a system high pressure of the multi-connection system, P_s represents a system low pressure of the multi-connection system, and R_o represents an oil storage coefficient of the indoor unit.

10. The oil return control method according to claim 9, wherein the step of "determining a system oil return time T of the multi-connection system" comprises:

acquiring a maximum oil storage quantity q_{max} of the indoor unit;
judging whether the maximum oil storage quantity q_{max} is larger than the maximum oil storage quantity threshold q_{smax};
if yes, determining the system oil return time T as the maximum oil return time threshold T_{smax}; otherwise, determining the system oil return time T according to the following formula:

$$\mathrm{T} = q_{max}/q_{smax} \times T_{smax}.$$

Patentansprüche

1. Ein Ölrücklaufsteuerungsverfahren für ein Mehranschlusssystem, wobei das Mehranschlusssystem mehrere Inneneinheiten umfasst, von denen mindestens eine nicht eingeschaltet ist, wobei das Ölrücklaufsteuerungsverfahren Folgendes umfasst:

Bestimmung der Ölspeichermenge q aller Inneneinheiten;
Bestimmung der Systemölrücklaufzeit T des Mehrfachanschlusssystems;
Bestimmung eines aktuellen Öffnungsgrades k eines Expansionsventils einer Inneneinheit, das nicht eingeschaltet ist, entsprechend der Ölspeichermenge q und der Systemölrücklaufzeit T;
Dadurch gekennzeichnet, dass das Ölrücklaufsteuerungsverfahren weiter umfasst:

Vergleich des aktuellen Öffnungsgrades k mit einer maximalen Öffnungsgradeschwelle ksmax und einer minimalen Öffnungsgradeschwelle ksmin; und
Selektives Einstellen des Öffnungsgrades des Expansionsventils der einen nicht eingeschalteten Inneneinheit gemäß einem Vergleichsergebnis und Halten des Expansionsventils im eingestellten Öffnungsgrad für die Systemölrücklaufzeit T.

2. Das Ölrücklaufsteuerverfahren gemäß Anspruch 1, wobei der Schritt "Ermittlung eines aktuellen Öffnungsgrades k eines Expansionsventils der einen Inneneinheit, die nicht gemäß der Ölspeichermenge q und der Systemölrücklaufzeit T eingeschaltet ist" insbesondere die Berechnung des aktuellen Öffnungsgrades k nach folgender Formel umfasst:

$$k = q(k_{smax} \times T_{smax})/(q_{smax} \times T)$$

wobei qsmax einen Schwellenwert für die maximale Ölspeichermenge der Inneneinheit darstellt, ksmax den maximalen Öffnungsgrad des Expansionsventils und Tsmax einen Schwellenwert für die maximale Systemölrücklaufzeit des Mehrfachverbindungssystems darstellt.

3. Das Ölrücklaufsteuerungsverfahren gemäß Anspruch 2, wobei der Schritt "selektiv den Öffnungsgrad des Expansionsventils der einen Inneneinheit, die nicht gemäß einem Vergleichsergebnis eingeschaltet ist, und das Expansionsventil im eingestellten Öffnungsgrad für die Systemölrücklaufzeit T" insbesondere umfasst:

Bestimmung einer Ölrücklaufzeit t der einen nicht eingeschalteten Inneneinheit nach folgender Formel, wenn k<ksmin:

$$t = (k \times \mathrm{T})/k_{smin}$$

Einstellung des Öffnungsgrades des Expansionsventils der einen Inneneinheit, die nicht auf ksmin eingeschaltet ist, und Halten des Expansionsventils am eingestellten Öffnungsgrad für die Zeit t; und

Einstellung des Öffnungsgrades des Expansionsventils auf Null, Halten des Expansionsventils am eingestellten Öffnungsgrad für eine Zeit T-t, und dann Rückkehr zum Schritt der Bestimmung q.

4. Das Ölrücklaufsteuerungsverfahren gemäß Anspruch 2, wobei der Schritt "selektiv den Öffnungsgrad des Expansionsventils der einen Inneneinheit, die nicht gemäß einem Vergleichsergebnis eingeschaltet ist, und das Expansionsventil im eingestellten Öffnungsgrad für die Systemölrücklaufzeit T" insbesondere umfasst:
Halten des Expansionsventils am aktuellen Öffnungsgrad k für die Systemölrücklaufzeit T, wenn ksmin≤k≤ksmax, und dann Rückkehr zum Schritt der Bestimmung q.

5. Das Ölrücklaufsteuerungsverfahren gemäß Anspruch 2, wobei der Schritt "selektiv den Öffnungsgrad des Expansionsventils der einen Inneneinheit, die nicht gemäß einem Vergleichsergebnis eingeschaltet ist, und das Expansionsventil im eingestellten Öffnungsgrad für die Systemölrücklaufzeit T" insbesondere umfasst:
Einstellung des Öffnungsgrades des Expansionsventils auf ksmax, wenn k>ksmax, Halten des Expansionsventils am eingestellten Öffnungsgrad für die Systemölrücklaufzeit T, und dann Rückkehr zum Schritt der Bestimmung q.

6. Das Ölrücklaufsteuerungsverfahren gemäß einem der Ansprüche 3 bis 5, wobei das Expansionsventil vor der Rückkehr zum Schritt der Bestimmung q im eingestellten Öffnungsgrad für eine Ölrücklaufintervall Ti in Betrieb gehalten wird.

7. Das Ölrücklaufsteuerungsverfahren gemäß Anspruch 6, wobei die Ölrücklaufintervallzeit Ti durch die folgenden Schritte bestimmt wird:

Ermittlung der Gesamtölspeichermenge Q des Mehrfachanschlusssystems nach folgender Formel:

$$\mathrm{Q} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{q_i}$$

Beurteilung, ob die Gesamtöllagermenge Q größer ist als die maximale Gesamtöllagermenge Qsmax;
wenn ja, bedeutet dies, dass das Expansionsventil mit dem eingestellten Öffnungsgrad für die Ölrücklaufzeit Ti betrieben hat;
wobei n die Anzahl der Inneneinheiten darstellt und qi die Ölspeichermenge der I Inneneinheit darstellt.

8. Das Ölrücklaufsteuerungsverfahren gemäß Anspruch 6, wobei die Ölrücklaufintervallzeit Ti durch die folgenden Schritte bestimmt wird:

Erwerb einer Abschaltzeit tsp der einen nicht eingeschalteten Inneneinheit; und
Beurteilung, ob die Abschaltzeit tsp größer oder gleich einer maximalen Abschaltzeitschwelle tspmax ist;
Wenn ja, bedeutet dies, dass das Expansionsventil mit dem eingestellten Öffnungsgrad für die Ölrücklaufzeit Ti betrieben hat.

9. Das Ölrücklaufsteuerverfahren gemäß einem der Ansprüche 1 bis 8, wobei die Ölspeichermenge q der Inneneinheit nach folgender Formel im Ölrücklaufsteuerverfahren bestimmt wird:

$$\mathrm{q} = P \times \mathrm{t}_{sp} \times (P_d - P_s) \times R_o$$

wobei P eine Leistung der Inneneinheit darstellt, tsp die Abschaltzeit der Inneneinheit darstellt, Pd einen Systemhochdruck des Mehrfachverbindungssystems darstellt, Ps einen Systemniederdruck des Mehrfachverbindungssystems und Ro einen Ölspeicherkoeffizienten der Inneneinheit darstellt.

10. Das Ölrücklaufsteuerungsverfahren gemäß Anspruch 9, wobei der Schritt der "Bestimmung einer Systemölrücklaufzeit T des Mehrfachanschlusssystems" umfasst:

Erwerb einer maximalen Öllagermenge qmax der Inneneinheit;
Beurteilung, ob die maximale Öllagermenge qmax größer ist als die maximale Öllagermenge qsmax;
falls ja, Bestimmung der Systemölrücklaufzeit T als Grenzwert für die maximale Ölrücklaufzeit Tsmax; andernfalls, Bestimmung der Systemölrücklaufzeit T nach folgender Formel:

$$T = q_{max}/q_{smax} \times T_{smax} \, .$$

Revendications

1. Procédé de contrôle de retour d'huile pour système multi - Connexions comprenant une pluralité d'unités intérieures dont au moins une unité intérieure n'est pas ouverte, **caractérisé en ce que** le procédé de contrôle de retour d'huile comprend:

   Déterminer la quantité d'huile stockée Q pour toutes les unités intérieures;
   Détermination du temps t de retour d'huile du système pour le système multi - Connexions;
   Déterminer l'ouverture courante K de la vanne de détente d'une unité intérieure non ouverte en fonction de la quantité d'huile stockée Q et du temps de retour d'huile T du système;
   Caractérisé en ce que le procédé de contrôle de retour d'huile comprend en outre:

      Comparer l'ouverture courante K à un seuil maximal d'ouverture ksmax et à un seuil minimal d'ouverture kstin; Et
      L'ouverture de la vanne de détente d'une unité intérieure non ouverte est réglée sélectivement en fonction des résultats de la comparaison et la vanne de détente est maintenue en fonctionnement à l'ouverture régulée pendant le temps t de retour d'huile du système.

2. Procédé de commande de retour d'huile selon la revendication 1, **caractérisé en ce que** l'étape de "détermination de l'ouverture courante K de la vanne de détente d'une unité intérieure non ouverte en fonction de la quantité d'huile stockée Q et du temps de retour d'huile T du système" consiste notamment à calculer l'ouverture courante k à l'aide de la formule suivante:

$$k = q(k_{smax} \times T_{smax})/(q_{smax} \times T)$$

   Où qsmax représente le seuil maximal de stockage d'huile de l'unité intérieure, ksmax représente le seuil maximal d'ouverture de la vanne de détente et tsmax représente le seuil maximal de temps de retour d'huile du système pour le système multiconnecteur.

3. Procédé de contrôle de retour d'huile selon la revendication 2, **caractérisé en ce que** l'étape consistent à "réguler sélectivement l'ouverture de la vanne de détente d'une unité intérieure non ouverte en fonction des résultats de la comparaison et à maintenir la vanne de détente en fonctionnement à l'ouverture régulée pendant le temps de retour d'huile t du système" comprend notamment:

   Si K < ksmin, le temps t de retour d'huile de l'unité intérieure pour une unité intérieure non ouverte est déterminé selon la formule suivante:

$$t = (k \times T)/k_{smin}$$

   Régler l'ouverture de la soupape de détente d'une machine intérieure non ouverte à ksmin et maintenir la soupape de détente en fonctionnement à l'ouverture régulée pendant un temps T; Et
   On règle l'ouverture de la vanne de détente à zéro, on fait fonctionner la vanne de détente à l'ouverture régulée pendant un temps t - t, puis on revient à l'étape de détermination de Q.

4. Procédé de contrôle de retour d'huile selon la revendication 2, **caractérisé en ce que** l'étape consistent à "réguler sélectivement l'ouverture de la vanne de détente d'une unité intérieure non ouverte en fonction des résultats de la comparaison et à maintenir la vanne de détente en fonctionnement à l'ouverture régulée pendant le temps de retour d'huile t du système" comprend notamment:
   Si ksmin ≤ K ≤ ksmax, on maintient la vanne de détente en fonctionnement à l'ouverture courante K pendant le temps t de retour du système, puis on revient à l'étape de détermination de Q.

5. Procédé de contrôle de retour d'huile selon la revendication 2, **caractérisé en ce que** l'étape consistent à "réguler sélectivement l'ouverture de la vanne de détente d'une unité intérieure non ouverte en fonction des résultats de la

comparaison et à maintenir la vanne de détente en fonctionnement à l'ouverture régulée pendant le temps de retour d'huile t du système" comprend notamment:
Si k > ksmax, on ajuste l'ouverture de la vanne de détente à ksmax, on maintient la vanne de détente en fonctionnement à l'ouverture ajustée pendant le temps t de retour du système, puis on revient à l'étape de détermination de Q.

6. Procédé de contrôle de retour d'huile selon l'une quelconque des revendications 3 à 5, **caractérisé en ce que**, avant de revenir à l'étape de détermination de Q, le détendeur est maintenu en fonctionnement pendant un intervalle de retour d'huile ti avec une ouverture régulée.

7. Procédé de contrôle de retour d'huile selon la revendication 6, **caractérisé en ce que** le temps d'intervalle de retour d'huile TI est déterminé par les étapes suivantes:

La quantité totale d'huile stockée Q pour un système multi - connexions est déterminée selon la formule suivante:

$$Q = \sum_{i=1}^{n} q_i$$

Juger si la quantité totale d'huile stockée Q est supérieure au seuil maximal de quantité totale d'huile stockée qsmax;
Si oui, cela signifie que le détendeur fonctionne à ouverture ajustée pendant l'intervalle de retour d'huile TI;
Où N représente le nombre d'unités intérieures et Qi la quantité d'huile stockée pour la I - ème unité intérieure.

8. Procédé de contrôle de retour d'huile selon la revendication 6, **caractérisé en ce que** le temps d'intervalle de retour d'huile TI est déterminé par les étapes suivantes:

Obtenir le temps d'arrêt TSP d'une unité intérieure non allumée; Et
Juger si le temps d'arrêt TSP est supérieur ou égal au seuil maximal de temps d'arrêt tspmax;
Si tel est le cas, cela signifie que le détendeur fonctionne à ouverture ajustée pendant l'intervalle de retour d'huile ti.

9. Procédé de contrôle de retour d'huile selon l'une quelconque des revendications 1 à 8, **caractérisé en ce que** la quantité Q d'huile stockée dans l'unité intérieure est déterminée dans le procédé de contrôle de retour d'huile selon la formule suivante:

$$q = P \times t_{sp} \times (P_d - P_s) \times R_o$$

Où P représente la puissance volumétrique de l'unité intérieure, tsp représente le temps d'arrêt de l'unité intérieure, Pd représente la haute pression du système du système multiplex, PS représente la basse pression du système du système multiplex et RO représente le coefficient de stockage d'huile de l'unité intérieure.

10. Procédé de contrôle de retour d'huile selon la revendication 9, **caractérisé en ce que** l'étape de détermination du temps de retour d'huile T du système multi - Connexions comprend:

Obtenir la quantité maximale d'huile stockée qmax pour l'unité intérieure;
Juger si la quantité maximale d'huile stockée qmax est supérieure au seuil de quantité maximale d'huile stockée qsmax;
Si tel est le cas, le temps de retour d'huile T du système est déterminé comme seuil maximal de temps de retour d'huile tsmax; Sinon, le temps t de retour d'huile du système est déterminé selon la formule suivante:

$$T = q_{max}/q_{smax} \times T_{smax}.$$

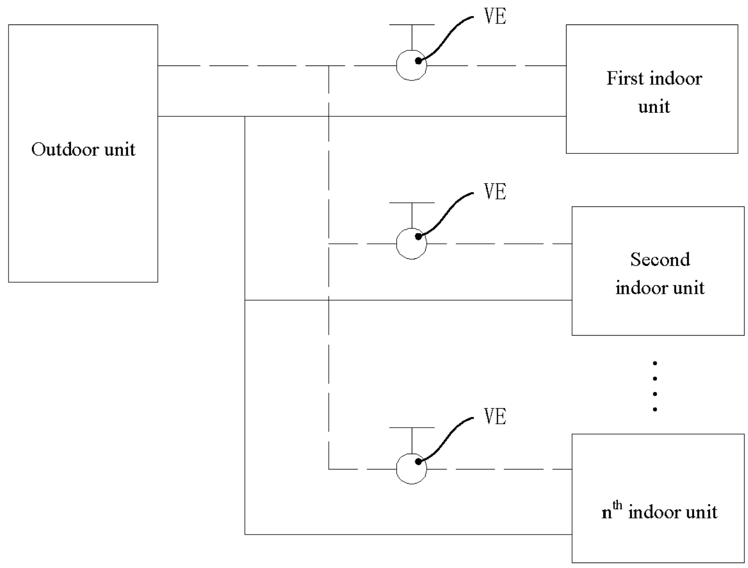

VE
Outdoor unit
First indoor unit
VE
Second indoor unit
VE
n^th indoor unit

FIG. 1

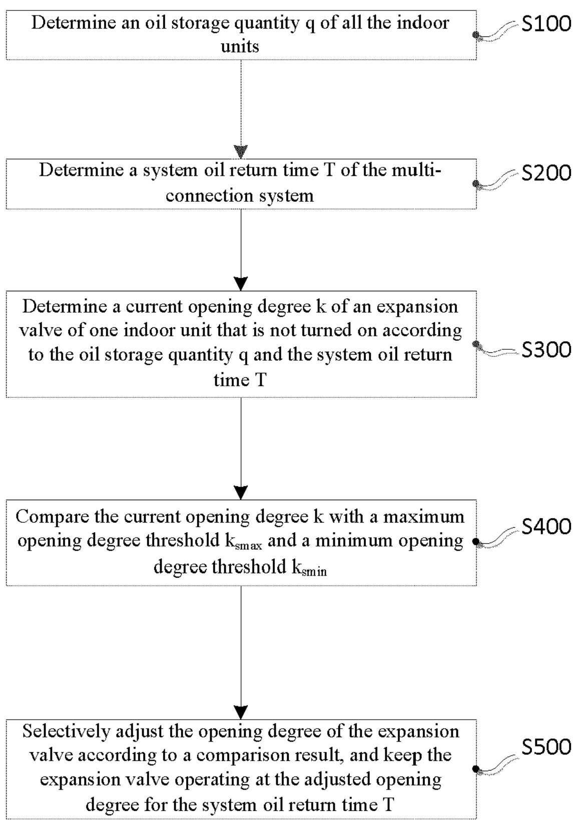

Determine an oil storage quantity q of all the indoor units
S100
Determine a system oil return time T of the multi-connection system
S200
Determine a current opening degree k of an expansion valve of one indoor unit that is not turned on according to the oil storage quantity q and the system oil return time T
S300
Compare the current opening degree k with a maximum opening degree threshold k_{smax} and a minimum opening degree threshold k_{smin}
S400
Selectively adjust the opening degree of the expansion valve according to a comparison result, and keep the expansion valve operating at the adjusted opening degree for the system oil return time T
S500

FIG. 2

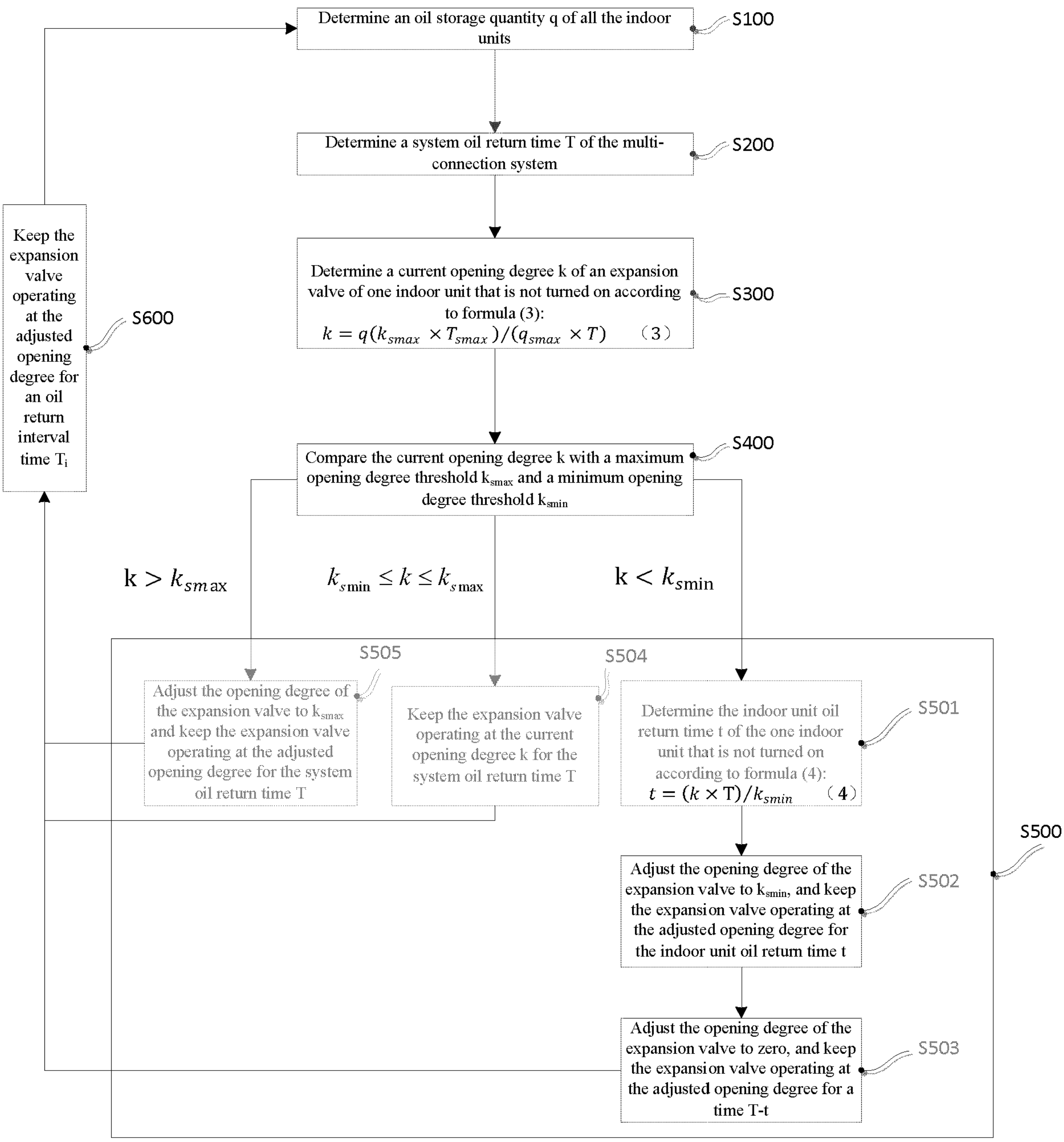

Determine an oil storage quantity q of all the indoor units
S100
Determine a system oil return time T of the multi-connection system
S200
Determine a current opening degree k of an expansion valve of one indoor unit that is not turned on according to formula (3):
$k = q(k_{smax} \times T_{smax})/(q_{smax} \times T)$ (3)
S300
Compare the current opening degree k with a maximum opening degree threshold k_{smax} and a minimum opening degree threshold k_{smin}
S400
$k > k_{smax}$
$k_{smin} \le k \le k_{smax}$
$k < k_{smin}$
Adjust the opening degree of the expansion valve to k_{smax} and keep the expansion valve operating at the adjusted opening degree for the system oil return time T
S505
Keep the expansion valve operating at the current opening degree k for the system oil return time T
S504
Determine the indoor unit oil return time t of the one indoor unit that is not turned on according to formula (4):
$t = (k \times T)/k_{smin}$ (4)
S501
Adjust the opening degree of the expansion valve to k_{smin}, and keep the expansion valve operating at the adjusted opening degree for the indoor unit oil return time t
S502
Adjust the opening degree of the expansion valve to zero, and keep the expansion valve operating at the adjusted opening degree for a time T-t
S503
S500
Keep the expansion valve operating at the adjusted opening degree for an oil return interval time T_i
S600

FIG. 3

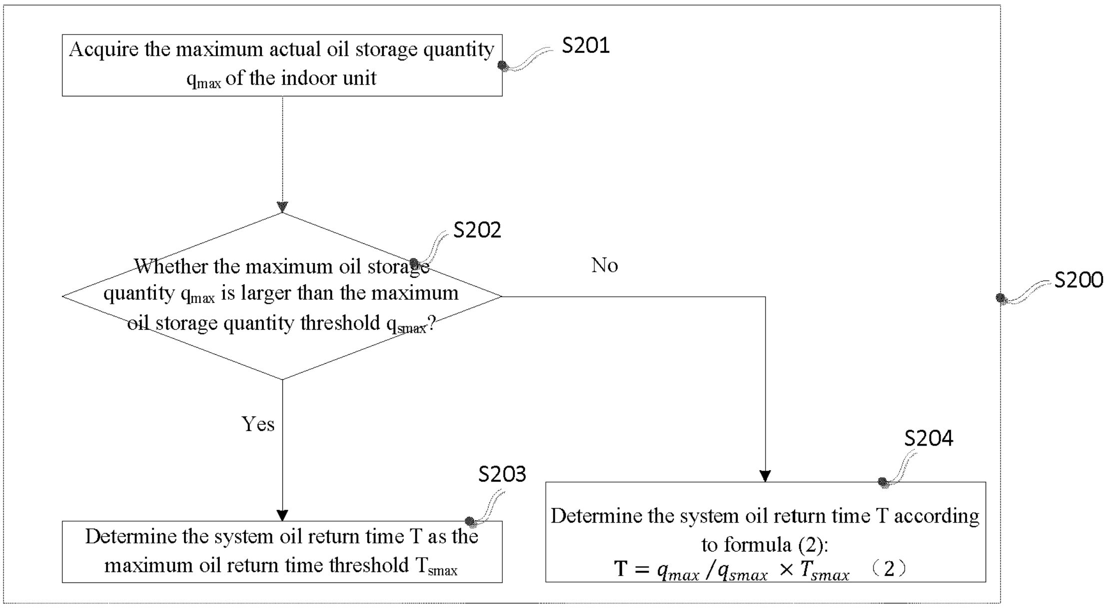
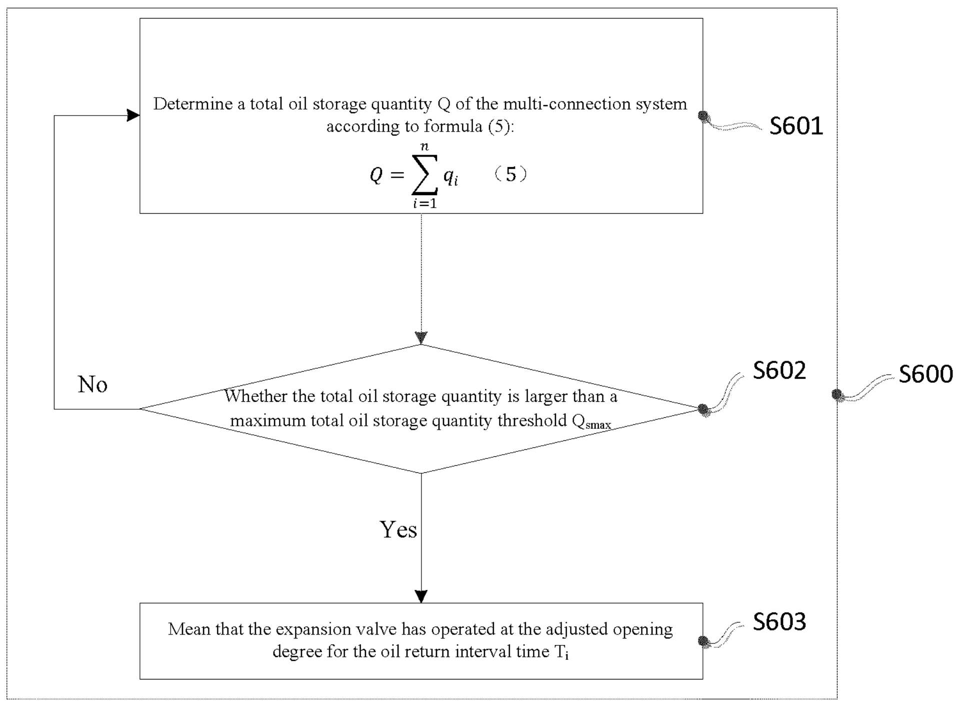
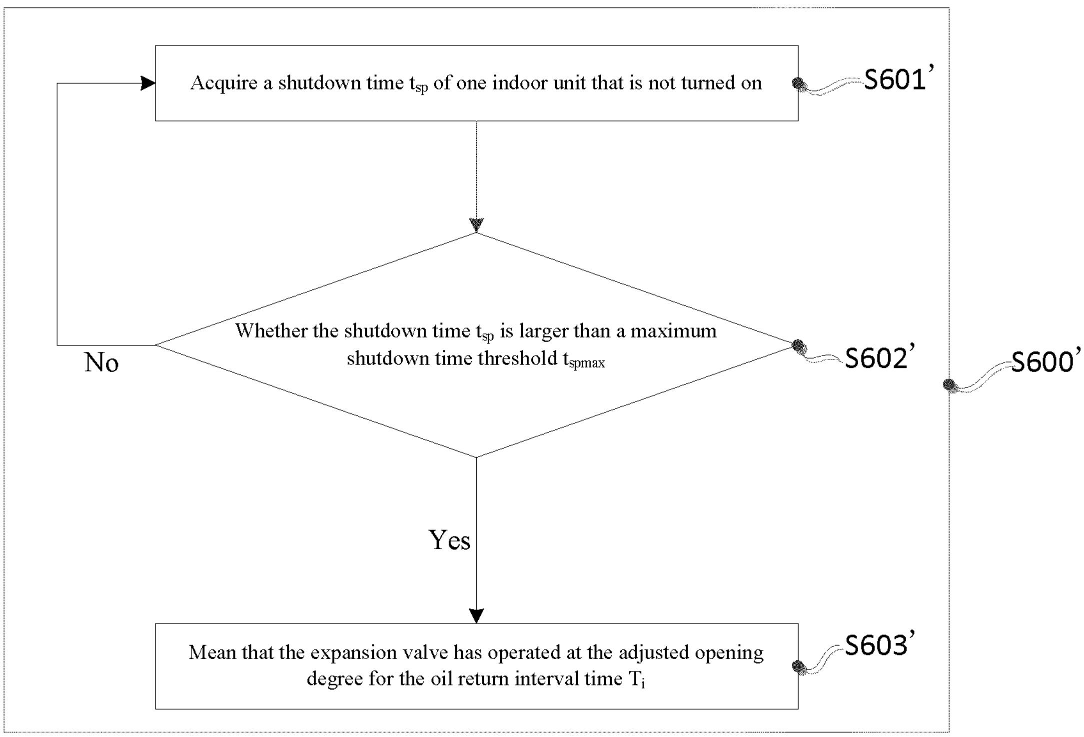

Acquire the maximum actual oil storage quantity q_{max} of the indoor unit
S201
Whether the maximum oil storage quantity q_{max} is larger than the maximum oil storage quantity threshold q_{smax}?
S202
No
S200
Yes
S204
S203
Determine the system oil return time T as the maximum oil return time threshold T_{smax}
Determine the system oil return time T according to formula (2):
$T = q_{max} / q_{smax} \times T_{smax}$ (2)

FIG. 4



Determine a total oil storage quantity Q of the multi-connection system according to formula (5):
$Q = \sum_{i=1}^{n} q_i$ （5）
S601
No
Whether the total oil storage quantity is larger than a maximum total oil storage quantity threshold Q_{smax}
S602
S600
Yes
Mean that the expansion valve has operated at the adjusted opening degree for the oil return interval time T_i
S603

FIG. 5



Acquire a shutdown time t_{sp} of one indoor unit that is not turned on
S601'
Whether the shutdown time t_{sp} is larger than a maximum shutdown time threshold t_{spmax}
No
S602'
S600'
Yes
Mean that the expansion valve has operated at the adjusted opening degree for the oil return interval time T_i
S603'

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 2019346188 A1 **[0003]**