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(71) Applicants:
- **Midea Group Co., Ltd.**
  528311 Foshan Guangdong (CN)
- **GD Midea Heating & Ventilating Equipment Co., Ltd.**
  528311 Foshan Guangdong (CN)

(72) Inventor: **Wenqiang, Chen**
Beijiao, Shunde, Foshan, Guangdong 528311 (CN)

(74) Representative: **Kudlek & Grunert Patentanwälte**
Postfach 33 04 29
80064 München (DE)

(54) Heat pump system and method for starting the same

(57) A heat pump system and a method for starting a heat pump system are provided. The method comprises: receiving a start instruction; controlling the heat pump system to enter a start mode according to the start instruction; recycling refrigerant in the heat pump system under the start mode; determining whether the start mode is completed; and if yes, controlling the heat pump system to enter an operation mode.

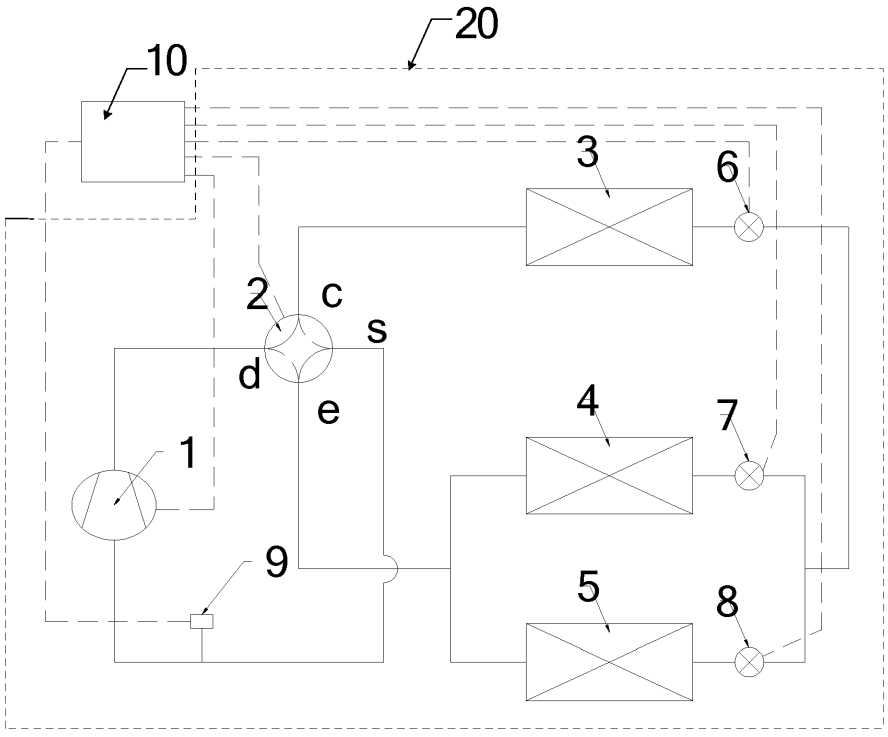

Fig. 1

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Description

FIELD

[0001] The present disclosure relates to a heat pump system and a method for starting a heat pump system.

BACKGROUND

[0002] With the development of heat pump technology, more and more heat pump products are put into the market. The more functions the heat pump product has, the more complex the heat pump product is, and the more heat exchangers are used in the heat pump product. For example, a multi-connected air conditioner has a plurality of indoor heat exchangers, and an air-source-heat recycling air-conditioning water heater not only has an air heat exchanger but also has a hot water heat exchanger. When not all the heat exchangers are used at one time, there will be refrigerant deposited in the unused heat exchanger, thus causing a change to the amount of refrigerant utilized in the systemic circulation. If this change is not controlled, it will seriously influence a safe operation of the heat pump system. Therefore, there is a need to improve a usage rate of the refrigerant and to reduce an influence of the deposited refrigerant on the heat pump system. The existing solutions comprise increasing the refrigerant charge and circulating the refrigerant in all the heat exchangers periodically.

[0003] However, the existing solutions have the following defects:

1. Although increasing the refrigerant charge can solve the problem of a shortage of operating refrigerant in some cases, the over-charged refrigerant will bring a potential danger to the heat pump system. For example, when there is no deposited refrigerant in some circulation, increasing the refrigerant charge will result in that there is too much refrigerant utilized in the systemic circulation, which is easy to produce a liquid strike, thus damaging a compressor of the heat pump system. Moreover, in order to avoid the above problem, it is necessary to increase some fluid reservoirs, which in turn increases the complexity and cost of the heat pump system.
2. Although circulating the refrigerant in all the heat exchangers periodically can solve the problem of oil return and redistribution of the refrigerant, all the heat exchangers should be started (including the unused heat exchangers) during the circulation, which will waste energy and cause inconveniences. Further, this method is only useful for the air conditioner that realizes heating and refrigeration separately, but useless for the multipurpose heat pump system (the refrigerant can't pass all the heat exchangers during one circulation).

SUMMARY

[0004] The aim of the present disclosure is to solve at least one of the problems in the related art.

[0005] According to embodiments of a first aspect of the present disclosure, a heat pump system is provided. The heat pump system comprises: a compressor and a four-way valve; an outdoor heat exchanger, connected with the compressor via the four-way valve; at least one indoor heat exchanger, connected with the compressor via the four-way valve; an outdoor control valve and at least one indoor control valve, in which the outdoor heat exchanger is connected in series with each of the at least one indoor heat exchanger via the outdoor control valve and via each of the at least one indoor control valve; and a controller, connected with the four-way valve, the outdoor control valve, the at least one indoor control valve and the compressor respectively, and configured to control the compressor, the four-way valve, the outdoor control valve and the at least one indoor control valve to open or close so as to control a circulation loop of the heat-pump system to enter the start mode or the operation mode, wherein the circulation loop is formed by the compressor, the four-way valve, the outdoor heat exchanger, the at least one indoor heat exchanger, the outdoor control valve and the at least one indoor control valve.

[0006] In some embodiments, the at least one indoor heat exchanger comprises a first indoor heat exchanger and a second indoor heat exchanger; the at least one indoor control valve comprises a first indoor control valve connected in series with the first indoor heat exchanger and a second indoor valve connected in series with the second indoor heat exchanger; the four-way valve comprises an discharge end, a condenser end, an evaporator end and a suction end, an discharge port and a suction port of the compressor are connected with the discharge end and the suction end of the four-way valve respectively; two ends of the outdoor heat exchanger are connected with the condenser end of the four-way valve and a first end of the outdoor control valve respectively, a second end of the outdoor control valve is connected with the first indoor control vale and the second indoor control valve respectively; the evaporator end of the four-way valve is connected with the first indoor heat exchanger and the second indoor heat exchanger respectively.

[0007] In some embodiments, the heat pump system further comprises a pressure sensor. The pressure sensor is disposed on a pipeline connecting the suction end of the four-way valve with the discharge port of the compressor, electrically connected with the controller and configured to detect a pressure at the suction port of the compressor.

[0008] In some embodiments, when the controller controls the four-way valve to power down, the discharge end is communicated with the condenser end, and the evaporator end is communicated with the suction end; when the controller controls the four-way valve to power on, the discharge end is communicated with the evapo-

rator end, and the condenser end is communicated with the suction end.

[0009] In some embodiments, when the heat pump system enters the start mode, the controller adjusts the four-way valve to control the outdoor heat exchanger to enter a heat dissipation state and to control the outdoor control valve to enter a closed state.

[0010] In some embodiments, the controller adjusts the four-way valve and the at least one indoor control valve to control the heat pump system to enter the operation mode and opens the outdoor control valve to adjust the operation mode.

[0011] In some embodiments, the operation mode is a full load refrigerating mode, a partial load refrigerating mode, a full load heating mode or a partial load heating mode.

[0012] In some embodiments, when the heat pump system is operating in the full load refrigerating mode, the discharge end is communicated with the condenser end, the evaporator end is communicated with the suction end, the outdoor control valve, the first indoor control valve and the second indoor control valve are open, the refrigerant passes the outdoor heat exchanger, the outdoor heat exchanger is used as a condenser and is in the heat dissipation state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

[0013] In some embodiments, when the heat pump system is operating in the partial load refrigerating mode, the discharge end is communicated with the condenser end, the evaporator end is communicated with the suction end, the outdoor control valve and one of the first indoor control valve and the second indoor control valve are open, the refrigerant passes the outdoor heat exchanger, the outdoor heat exchanger is used as a condenser and is in the heat dissipation state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

[0014] In some embodiments, when the heat pump system is operating in the full load heating mode, the discharge end is communicated with the evaporator end, the condenser end is communicated with the suction end, the outdoor control valve, the first indoor control valve and the second indoor control valve are open, the refrigerant passes the outdoor heat exchanger, the outdoor heat exchanger is used as an evaporator and is in a heat absorption state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

[0015] In some embodiments, when the heat pump system is operating in the partial load heating mode, the discharge end is communicated with the evaporator end, the condenser end is communicated with the suction end, the outdoor control valve and one of the first indoor control valve and the second indoor control valve are open, the refrigerant passes the outdoor heat exchanger, the outdoor heat exchanger is used as an evaporator and is in a heat absorption state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

[0016] According to embodiments of a second aspect of the present disclosure, a method for starting a heat pump system is provided. The method comprises: receiving a start instruction; controlling the heat pump system to enter a start mode according to the start instruction; recycling refrigerant in the heat pump system under the start mode; determining whether the start mode is completed; and if yes, controlling the heat pump system to enter an operation state.

[0017] In some embodiments, the heat pump system comprises a compressor and a four-way valve, an outdoor heat exchanger connected with the compressor via the four-way valve, at least one indoor heat exchanger connected with the compressor via the four-way valve, and an outdoor control valve and at least one indoor control valve, the outdoor heat exchanger is connected in series with each of the at least one indoor heat exchanger via the outdoor control valve and via each of the at least one indoor control valve.

[0018] In some embodiments, controlling the heat pump system to enter a start mode comprises: adjusting the four-way valve to control the outdoor heat exchanger to enter the heat dissipation state and to control the outdoor control valve to enter the closed state.

[0019] In some embodiments, controlling the heat pump system to enter the operation mode comprises: adjusting the four-way valve and the at least one indoor control valve to control the heat pump system to enter the operation mode; and opening the outdoor control valve to adjust the operation mode.

[0020] In some embodiments, the start mode is determined to be completed when any of the following conditions is satisfied: a suction pressure of the compressor is lower than a first preset pressure; a suction pressure of the compressor is lower than a second preset pressure for a first preset time; a suction pressure of the compressor is lower than a switch threshold of a suction pressure switch of the compressor for a second preset time; and a recycle time of the refrigerant reaches a third preset time.

[0021] According to the heat pump system or the method for starting the heat pump system of the present disclosure, by recycling refrigerant in the heat pump system into the heat exchanger to be used for circulation, a reasonable distribution of the refrigerant is realized, without increasing the refrigerant charge. Moreover, there is no need to start all the heat exchangers, thus saving energy and reducing the influence of the distribution of the refrigerant on the operation of the heat pump system. In addition, the technical solutions of the present disclosure have a wide range of application and can be widely applied to a variety of equipments which need the distribution of the refrigerant.

[0022] These and other aspects and advantages of the invention will be present in the following description, and part of them will become apparent or be understood through the embodiment of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following descriptions taken in conjunction with the drawings in which:

Fig. 1 is a schematic view of a heat pump system according to an embodiment of the present disclosure;
Fig. 2 is a block diagram of a controller according to an embodiment of the present disclosure;
Figs. 3-6 are schematic views showing flow paths of refrigerant in the heat pump system of Fig. lunder different operation modes;
Fig. 7 is a flow chart of a method for starting a heat pump system according to an embodiment of the present disclosure;
Fig. 8 is a flow chart of a method for controlling the heat pump system to enter a partial load heating mode according to an embodiment of the present disclosure; and
Fig. 9 is a flow chart of a method for controlling the heat pump system to enter a partial load refrigerating mode according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0024] Reference will be made in detail to embodiments of the present disclosure. The embodiments described herein with reference to drawings are explanatory, illustrative, and used to generally understand the present disclosure. The embodiments shall not be construed to limit the present disclosure. The same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions.

[0025] In the specification, unless specified or limited otherwise, relative terms such as "central", "longitudinal", "lateral", "front", "rear", "right", "left", "inner", "outer", "lower", "upper", "horizontal", "vertical", "above", "below", "up", "top", "bottom", "peripheral" as well as derivative thereof (e.g., "horizontally", "downwardly", "upwardly", etc.) should be construed to refer to the orientation as then described or as shown in the drawings under discussion. These relative terms are for convenience of description and do not require that the present disclosure be constructed or operated in a particular orientation. In addition, terms such as "first" and "second" are used herein for purposes of description and are not intended to indicate or imply relative importance or significance.

[0026] In the following, a heat pump system and a method for starting the heat pump system according to embodiments of the present disclosure will be described in detail with reference to drawings.

[0027] Fig. 1 is a schematic view of a heat pump system according to an embodiment of the present disclosure. As shown in Fig. 1, the heat pump system 20 comprises a compressor 1, a four-way valve 2, an outdoor heat exchanger 3, a first indoor heat exchanger 4, a second indoor heat exchanger 5, an outdoor control valve 6, a first indoor control valve 7, a second indoor control valve 8 and a controller 10.

[0028] The outdoor heat exchanger 3, the first indoor heat exchanger 4 and the second indoor heat exchanger 5 are connected with the compressor 1 respectively via the four-way valve 2. The outdoor heat exchanger 3 is connected in series with the first indoor heat exchanger 4 via the outdoor control valve 6 and the first indoor control valve 7. The outdoor heat exchanger 3 is connected in series with the second indoor heat exchanger 5 via the outdoor control valve 6 and the second indoor control valve 8. The compressor 1, the four-way valve 2, the outdoor heat exchanger 3, the first indoor heat exchanger 4, the second indoor heat exchange 5, the outdoor control valve 6 and the first indoor control valve 7 and the second indoor control valve 8 connected with each other form a circulation loop.

[0029] The controller 10 is electrically connected with the four-way valve 2, the outdoor control valve 6, the first indoor control valve 7, the second indoor control valve 8 and the compressor 1, and is configured to control the compressor 1, the four-way valve 2, the outdoor control valve 6, the first indoor control valve 7 and the second indoor control valve 8 to open or close so as to control the heat pump system 20 to enter a start mode or an operation mode.

[0030] It should be understood that, the heat pump system 20 shown in Fig. 1 is only illustrative, and is not used to limit the scope of the present disclosure. The heat pump system according to the present disclosure may comprise any number of indoor heat exchangers and a same number of indoor control valves. In other words, the heat pump system may comprise at least one indoor heat exchanger and at least one indoor control valves. The at least one indoor heat exchanger is connected with the compressor 1 via the four-way valve 2. The outdoor heat exchanger 3 is connected in series with each of the at least one indoor heat exchanger via the outdoor control valve 6 and via each of the at least one indoor control valve. The circulation loop is formed by the compressor 1, the four-way valve 2, the outdoor heat exchanger 3, the at least one indoor heat exchanger, the outdoor control valve 6 and the at least one indoor control valve.

[0031] Specifically, as shown in Fig. 1, the four-way valve 2 comprises a discharge end (d), a condenser end (c), an evaporator end (e) and a suction end (s). A discharge port and a suction port of the compressor 1 are connected with the discharge end (d) and the suction end (s) of the four-way valve 2 respectively. Two ends of the outdoor heat exchanger 3 are connected with the condenser end (c) of the four-way valve 2 and a first end of the outdoor control valve 6 respectively. A second end of the outdoor control valve 6 is connected with the first indoor control vale 7 and the second indoor control valve

8 respectively. The evaporator end (e) of the four-way valve 2 is connected with the first indoor heat exchanger 4 and the second indoor heat exchanger 5 respectively.

[0032] In one embodiment, when the controller 10 controls the four-way valve 2 to power down, the discharge end (d) is communicated with the condenser end (c), and the evaporator end (e) is communicated with the suction end (s). When the controller 10 controls the four-way valve 2 to power on, the discharge end (d) is communicated with the evaporator end (e), and the condenser end (c) is communicated with the suction end (s).

[0033] Fig. 2 is a block diagram of the controller 10 according to an embodiment of the present disclosure. As shown in Fig. 2, the controller 10 comprises a receiving module 110, a first executing module 120, a determining module 130 and a second executing module 140. The receiving module 110 is configured to receive a start instruction. The first executing module 120 is electrically connected with the receiving device 110 and is configured to control the heat pump system to enter a start mode according to the start instruction, and to control the refrigerant in the circulation loop to be recycled under the start mode. The determining module 130 is configured to determine whether the start mode is completed. The second executing module 140 is electrically connected with the determining module 130, and is configured to control the heat pump system 20 to enter the operation mode when the start mode is completed.

[0034] In order to facilitate determining whether the refrigerant in the circulation loop is recycled completely, a pressure sensor 9 may be disposed on a pipeline connecting the suction end (s) of the four-way valve 2 with the discharge port of the compressor 1. The pressure sensor 9 is electrically connected with the controller 10 and is configured to detect a pressure at the suction port of the compressor 1. In one embodiment, when the pressure sensor 9 detects that the pressure at the suction port of the compressor 1 is 0 MPa or when the operating time of the compressor 1 during the start mode exceeds 30 seconds, it is determined that the start mode is completed.

[0035] Specifically, when the heat pump system 20 enters the start mode, the first executing module 120 adjusts the four-way valve 2 to control the outdoor heat exchanger 3 to enter a heat dissipation state and to control the outdoor control valve 6 to enter a closed state. When the heat pump system 20 completes the start mode, the second executing module 140 adjusts the four-way valve 2, the first indoor control valve 7 and the second indoor control valve 8 to control the heat pump system 20 to enter the operation mode and opens the outdoor control valve 6 to adjust the operation mode.

[0036] The first executing module 120 and the second executing module 130 may be independently disposed, or may be integrated into a single chip.

[0037] The operation mode of the heat pump system 20 is a full load refrigerating mode, a partial load refrigerating mode, a full load heating mode or a partial load heating mode.

[0038] Figs. 3-6 are schematic views showing flow paths of refrigerant in the heat pump system 20 under different operation modes. As shown in Fig. 3, when the heat pump system 20 is operating in the full load refrigerating mode, the four-way valve 2 is powered down, i.e., the discharge end (d) is communicated with the condenser end (c), the evaporator end (e) is communicated with the suction end (s). The outdoor control valve 6, the first indoor control valve 7 and the second indoor control valve 8 are open. The flow path of the refrigerant is as follows: the discharge port of the compressor 1→ the discharge end (d)→ the condenser end (c)→ the outdoor heat exchanger 3→ the outdoor control valve 6→ the first indoor control valve 7 and the second indoor control valve 8→ the first indoor heat exchanger 4 and the second indoor heat exchanger 5→ the evaporator end (e) → the suction end (s)→ the suction port of the compressor 1. In this mode, the refrigerant passes the outdoor heat exchanger 3, the outdoor heat exchanger 3 is used as a condenser and is in the heat dissipation state, and the outdoor control valve 6 is used as an outlet control valve for the outdoor heat exchanger 3.

[0039] As shown in Fig. 4, when the heat pump system 20 is operating in the partial load refrigerating mode, the four-way valve 2 is powered down, i.e., the discharge end (d) is communicated with the condenser end (c), the evaporator end (e) is communicated with the suction end (s). The outdoor control valve 6 and one of the first indoor control valve 7 and the second indoor control valve 8 are open. The flow path of the refrigerant is as follows: the discharge port of the compressor 1→ the discharge end (d)→ the condenser end (c)→ the outdoor heat exchanger 3→ the outdoor control valve 6→ the first indoor control valve 7 or the second indoor control valve 8→ the firs indoor heat exchanger 4 or the second indoor heat exchanger 5→ the evaporator end (e)→ the suction end (s)→ the suction port of the compressor 1. In this mode, the refrigerant passes the outdoor heat exchanger 3, the outdoor heat exchanger 3 is used as a condenser and is in the heat dissipation state, and the outdoor control valve 6 is used as an outlet control valve for the outdoor heat exchanger 3.

[0040] As shown in Fig. 5, when the heat pump system 20 is operating in the full load heating mode, the four-way valve 2 is powered on, i.e., the discharge end (d) is communicated with the evaporator end (e), the condenser end (c) is communicated with the suction end (s). The outdoor control valve 6, the first indoor control valve 7 and the second indoor control valve (8) are open. The flow path of the refrigerant is as follows: the discharge port of the compressor 1→ the discharge end (d)→ the evaporator end (e)→ the first indoor heat exchanger 4 and the second indoor heat exchanger 5→ the first indoor control valve 7 and the second indoor control valve 8→ the outdoor control valve 6→ the outdoor heat exchanger 3→ the condenser end (c)→ the suction end (s)→ the suction port of the compressor 1. In this mode, all the

refrigerant passes the outdoor heat exchanger 3, the outdoor heat exchanger 3 is used as an evaporator and is in a heat absorption state, and the outdoor control valve 6 is used as an outlet control valve for the outdoor heat exchanger 3.

[0041] As shown in Fig. 6, when the heat pump system 20 is operating in the full load heating mode, the four-way valve 2 is powered on, i.e., the discharge end (d) is communicated with the evaporator end (e), the condenser end (c) is communicated with the suction end (s). The outdoor control valve 6 and one of the first indoor control valve 7 and the second indoor control valve 8 are open. The flow path of the refrigerant is as follows: the discharge port of the compressor 1→ the discharge end (d)→ the evaporator end (e)→ the first indoor heat exchanger 4 or the second indoor heat exchanger 5→ the first indoor control valve 7 or the second indoor control valve 8→ the outdoor control valve 6→ the outdoor heat exchanger 3→ the condenser end (c)→ the suction end (s) → the suction port of the compressor 1. In this mode, the refrigerant passes the outdoor heat exchanger 3, the outdoor heat exchanger 3 is used as an evaporator and is in a heat absorption state, and the outdoor control valve 6 is used as an outlet control valve for the outdoor heat exchanger 3.

[0042] According to the heat pump system of the present disclosure, by recycling the refrigerant in the circulation loop into the heat exchanger to be used for circulation, a reasonable distribution of the refrigerant in the heat pump system is realized, without increasing the refrigerant charge. Moreover, there is no need to start all the heat exchangers, thus saving energy and reducing the influence of the distribution of the refrigerant on the operation of the heat pump system. In addition, the controller has a wide range of application and can be widely applied to a variety of equipments which need the distribution of the refrigerant.

[0043] Fig. 7 is a flow chart of a method for starting the above heat pump system. As shown in Fig. 7, the method comprises the following steps.

[0044] At step S1, a start instruction is received.

[0045] At step S2, the heat pump system is controlled to enter a start mode according to the start instruction.

[0046] At step S3, the refrigerant in the heat pump system is recycled. Specifically, when the heat pump system enters the start mode, the controller adjusts the four-way valve to control the outdoor heat exchanger to enter the heat dissipation state and to control the outdoor control valve to enter the closed state, so as to recycle the refrigerant in the heat pump system under the start mode.

[0047] At step S4, it is determined whether the start mode is completed. Specifically, the start mode is determined to be completed when any of the following conditions is satisfied: (1) a suction pressure of the compressor is lower than a first preset pressure; (2) a suction pressure of the compressor is lower than a second preset pressure for a first preset time; (3) a suction pressure of the compressor is lower than a switch threshold of a suction pressure switch of the compressor for a second preset time; (4) a recycle time of the refrigerant reaches a third preset time. In one embodiment, the first preset pressure is -0.1-8 MPa, the second preset pressure is -0.1-8 MPa, the first preset time is 0-180 seconds, the switch threshold of the suction pressure switch is -0.1-8 MPa; the second preset time is 0-180 seconds, and the third preset time is 1-180 seconds.

[0048] At step S5, the heat pump system is controlled to enter an operation mode when the start mode is completed. Specifically, the controller adjusts the four-way valve and the at least one indoor control valve to control the heat pump system to enter the operation mode, and then opens the outdoor control valve to adjust the operation mode. In one embodiment, the operation mode comprises a full load refrigerating mode, a partial load refrigerating mode, a full load heating mode or a partial load heating mode.

[0049] According to the method for starting the heat pump system of the present disclosure, by recycling the refrigerant in the heat pump system into the heat exchanger to be used for circulation, a reasonable distribution of the refrigerant in the heat pump system is realized, without increasing the refrigerant charge. Moreover, with the method for starting the heat pump system according to embodiments of the present disclosure, there is no need to start all the heat exchangers, thus saving energy and reducing the influence of the distribution of the refrigerant on the operation of the heat pump system. In addition, the method according to the present disclosure has a wide range of application and can be widely applied to a variety of equipments which need the distribution of the refrigerant.

[0050] Fig. 8 is a flow chart of a method for controlling the heat pump system to enter a partial load heating mode according to an embodiment of the present disclosure. As shown in Fig. 8, the method comprises the following steps.

[0051] At step S11, a start instruction is received. The start instruction indicates that the heat pump system is desired to enter the partial load heating mode.

[0052] At step S21, the heat pump system is controlled to enter a start mode according to the start instruction.

[0053] At step S31, the refrigerant in the heat pump system is recycled under the start mode. Specifically, the controller adjusts the four-way valve to power down to make the outdoor heat exchanger enter a heat dissipation state and closes the outdoor control valve, such that the refrigerant is recycled.

[0054] At step S41, it is determined whether the start mode is completed. Specifically, when a suction pressure of the compressor is lower than a first preset pressure and/or when the recycle time of the refrigerant reaches a preset time, it is determined that the start mode is completed.

[0055] At step S51, the heat pump system is controlled to enter an operation state when the start mode is completed. Specifically, when the start mode is completed,

the controller adjusts the four-way valve to power on and controls the outdoor control valve 6 to enter the operation state.

[0056] Fig. 9 is a flow chart of a method for controlling the heat pump system to enter a partial load refrigerating mode according to an embodiment of the present disclosure. As shown in Fig. 9, the method comprises the following steps.

[0057] At step S12, a start instruction is received. The start instruction indicates that the heat pump system is desired to enter the partial load refrigerating mode.

[0058] At step S22, the heat pump system is controlled to enter a start mode according to the start instruction.

[0059] At step S32, the refrigerant in the heat pump system is recycled under the start mode. Specifically, the controller adjusts the four-way valve to power down to make the outdoor heat exchanger enter the heat dissipation state and closes the outdoor control valve, such that the refrigerant is recycled.

[0060] At step S41, it is determined whether the start mode is completed. Specifically, when a suction pressure of the compressor is lower than a first preset pressure and/or when the recycle time of the refrigerant reaches a preset time, it is determined that the start mode is completed.

[0061] At step S51, the heat pump system is controlled to enter an operation state when the start mode is completed. Specifically, when the start mode is completed, the controller adjusts the four-way valve to power on and controls the outdoor control valve to enter the operation state.

[0062] According to the method for starting the heat pump system of the present disclosure, by recycling the refrigerant in the heat pump system into the heat exchanger to be used for circulation, a reasonable distribution of the refrigerant in the heat pump system is realized without increasing the refrigerant charge, and the refrigerant is prevented from depositing into the second indoor heat exchanger during downtime, thus saving energy and reducing the influence of the distribution of the refrigerant on the operation of the heat pump system. In addition, the method according to the present disclosure has a wide range of application and can be widely applied to a variety of equipments which need the distribution of the refrigerant.

[0063] According to the method for starting the heat pump system of the present disclosure, the refrigerant is distributed before the heat pump system enters the operation mode (i.e., the refrigerant is distributed during the start control for the heat pump system), and when the start control for the heat pump system is completed, there is no need to distribute the refrigerant during the operation mode of the heat pump system, which does not break the balance of the operation and improves the conveniences. Specifically, with the method of the present disclosure, at every time when the heat pump system starts, almost all of the refrigerant in the heat pump system is recycled into one heat exchanger, and is utilized by each circulation, which can realize a reasonable distribution of the refrigerant without additionally increasing the refrigerant charge, thus avoiding a negative impact on the heat pump system caused by too much refrigerant. In addition, with the method according to the present disclosure, it is not necessary for all the heat exchangers to participate in a same circulation procedure, which greatly simplifies the system design and reduces the energy cost of the system. Thus, the method can be widely applied to a variety of products needing the distribution of the refrigerant, such as a multi-connected air-conditioner unit, a unit type heat-recycle air-conditioning water heater unit, a multi-connected heat-recycle air-conditioning water heater unit, a three-tube multi-connected unit, and a multi-functional multi-heat-resource heat pump unit. Certainly, the method will not occupy too much operation time of the heat pump system, and has an advantage of high distribution efficiency.

[0064] In the description of the present disclosure, it should be noticed that unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. For the general technician in the field, the above terms can be understood according to the detail embodiment of the present disclosure.

[0065] Reference throughout this specification to "an embodiment," "some embodiments," "one embodiment", "another example," "an example," "a specific example," or "some examples," means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. Thus, the appearances of the phrases throughout this specification are not necessarily referring to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples.

[0066] Although explanatory embodiments have been shown and described, it would be appreciated by those skilled in the art that the above embodiments cannot be construed to limit the present disclosure, and changes, alternatives, and modifications can be made in the embodiments without departing from spirit, principles and scope of the present disclosure.

Claims

1. A heat pump system, comprising:

a compressor and a four-way valve;
an outdoor heat exchanger, connected with the compressor via the four-way valve;
at least one indoor heat exchanger, connected with the compressor via the four-way valve;

and

an outdoor control valve and at least one indoor control valve, wherein the outdoor heat exchanger is connected in series with each of the at least one indoor heat exchanger via the outdoor control valve and via each of the at least one indoor control valve, and

a controller, connected with the four-way valve, the outdoor control valve, the at least one indoor control valve and the compressor respectively, and configured to control the compressor, the four-way valve, the outdoor control valve and the at least one indoor control valve to open or close so as to control a circulation loop of the heat-pump system to enter the start mode or the operation mode, wherein the circulation loop is formed by the compressor, the four-way valve, the outdoor heat exchanger, the at least one indoor heat exchanger, the outdoor control valve and the at least one indoor control valve.

2. The heat pump system according to claim 1, wherein the at least one indoor heat exchanger comprises a first indoor heat exchanger and a second indoor heat exchanger; the at least one indoor control valve comprises a first indoor control valve connected in series with the first indoor heat exchanger and a second indoor valve connected in series with the second indoor heat exchanger; the four-way valve comprises an discharge end, a condenser end, an evaporator end and a suction end, an discharge port and a suction port of the compressor are connected with the discharge end and the suction end of the four-way valve respectively; two ends of the outdoor heat exchanger are connected with the condenser end of the four-way valve and a first end of the outdoor control valve respectively, a second end of the outdoor control valve is connected with the first indoor control vale and the second indoor control valve respectively; the evaporator end of the four-way valve is connected with the first indoor heat exchanger and the second indoor heat exchanger respectively.

3. The heat pump system according to claim 2, further comprising:

a pressure sensor, disposed on a pipeline connecting the suction end of the four-way valve with the discharge port of the compressor, electrically connected with the controller and configured to detect a pressure at the suction port of the compressor.

4. The heat pump system according to claim 2, wherein when the controller controls the four-way valve to power down, the discharge end is communicated with the condenser end, and the evaporator end is communicated with the suction end; when the controller controls the four-way valve to power on, the discharge end is communicated with the evaporator end, and the condenser end is communicated with the suction end.

5. The heat pump system according to any of claims 1-4, wherein when the heat pump system enters the start mode, the controller adjusts the four-way valve to control the outdoor heat exchanger to enter a heat dissipation state and to control the outdoor control valve to enter a closed state.

6. The heat pump system according to claim 5, wherein the controller adjusts the four-way valve and the at least one indoor control valve to control the heat pump system to enter the operation mode and opens the outdoor control valve to adjust the operation mode.

7. The heat-pump system according to any of claims 1-6, wherein the operation mode is a full load refrigerating mode, a partial load refrigerating mode, a full load heating mode or a partial load heating mode.

8. The heat pump system according to claim 7, wherein when the heat pump system is operating in the full load refrigerating mode, the discharge end is communicated with the condenser end, the evaporator end is communicated with the suction end, the outdoor control valve, the first indoor control valve and the second indoor control valve are open, all the refrigerant passes the outdoor heat exchanger, the outdoor heat exchanger is used as a condenser and is in the heat dissipation state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

9. The heat pump system according to claim 7, wherein when the heat pump system is operating in the partial load refrigerating mode, the discharge end is communicated with the condenser end, the evaporator end is communicated with the suction end, the outdoor control valve and one of the first indoor control valve and the second indoor control valve are open, the refrigerant passes the outdoor heat exchanger, the outdoor heat exchanger is used as a condenser and is in the heat dissipation state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

10. The heat pump system according to claim 7, wherein when the heat pump system is operating in the full load heating mode, the discharge end is communicated with the evaporator end, the condenser end is communicated with the suction end, the outdoor control valve, the first indoor control valve and the second indoor control valve are open, the refrigerant passes the outdoor heat exchanger, the outdoor heat

exchanger is used as an evaporator and is in a heat absorption state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

11. The heat pump system according to claim 7, wherein when the heat pump system is operating in the partial load heating mode, the discharge end is communicated with the evaporator end, the condenser end is communicated with the suction end, the outdoor control valve and one of the first indoor control valve and the second indoor control valve are open, determine the refrigerant passes the outdoor heat exchanger, the outdoor heat exchanger is used as an evaporator and is in a heat absorption state, and the outdoor control valve is used as an outlet control valve for the outdoor heat exchanger.

12. A method for starting a heat pump system, comprising:

receiving a start instruction;
controlling the heat pump system to enter a start mode according to the start instruction;
recycling refrigerant in the heat pump system under the start mode;
determining whether the start mode is completed; and
if yes, controlling the heat pump system to enter an operation mode.

13. The method according to claim 12, wherein the heat pump system comprises a compressor and a four-way valve, an outdoor heat exchanger connected with the compressor via the four-way valve, at least one indoor heat exchanger connected with the compressor via the four-way valve, and an outdoor control valve and at least one indoor control valve, the outdoor heat exchanger is connected in series with each of the at least one indoor heat exchanger via the outdoor control valve and via each of the at least one indoor control valve, and the method further comprises:

adjusting the four-way valve to control the outdoor heat exchanger to enter the heat dissipation state and to control the outdoor control valve to enter the closed state, so as to recycle the refrigerant in the heat pump system under the start mode, and

14. The method according to claim 12 or 13, wherein controlling the heat pump system to enter the operation mode comprises:

adjusting the four-way valve and the at least one indoor control valve to control the heat pump system to enter the operation mode; and
opening the outdoor control valve to adjust the operation mode.

15. The method according to any of claims 12-14, wherein the start mode is determined to be completed when any of the following conditions is satisfied:

a suction pressure of the compressor is lower than a first preset pressure;
a suction pressure of the compressor is lower than a second preset pressure for a first preset time;
a suction pressure of the compressor is lower than a switch threshold of a suction pressure switch of the compressor for a second preset time; and
a recycle time of the refrigerant reaches a third preset time.

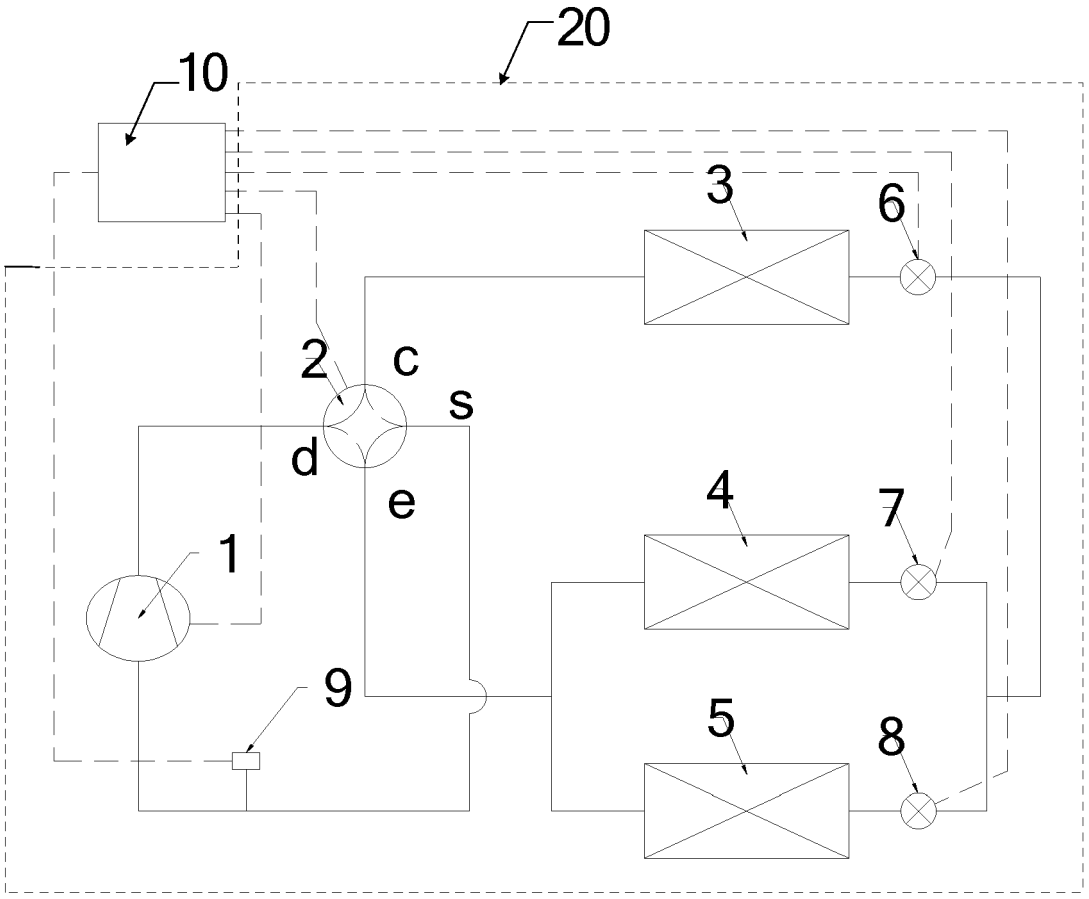
20
10
3
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Fig. 1

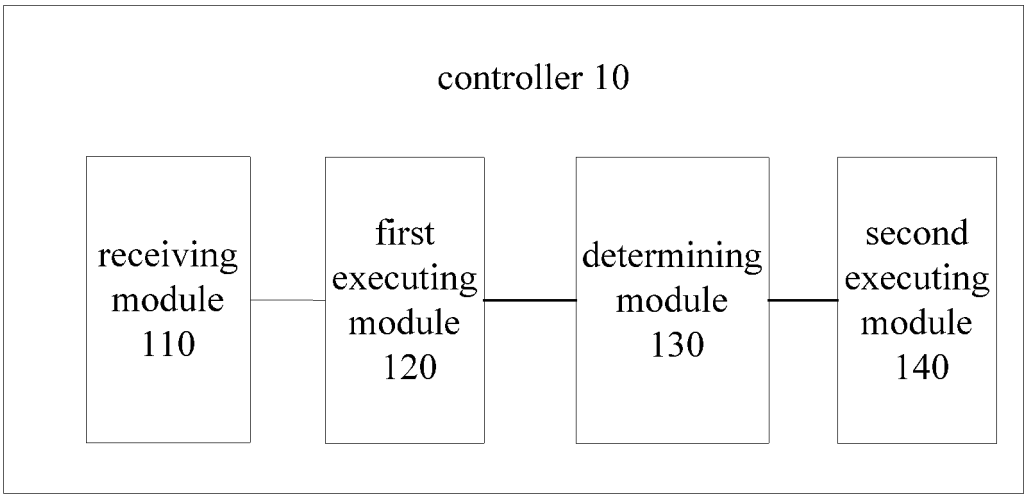
controller 10
receiving module 110
first executing module 120
determining module 130
second executing module 140

Fig. 2

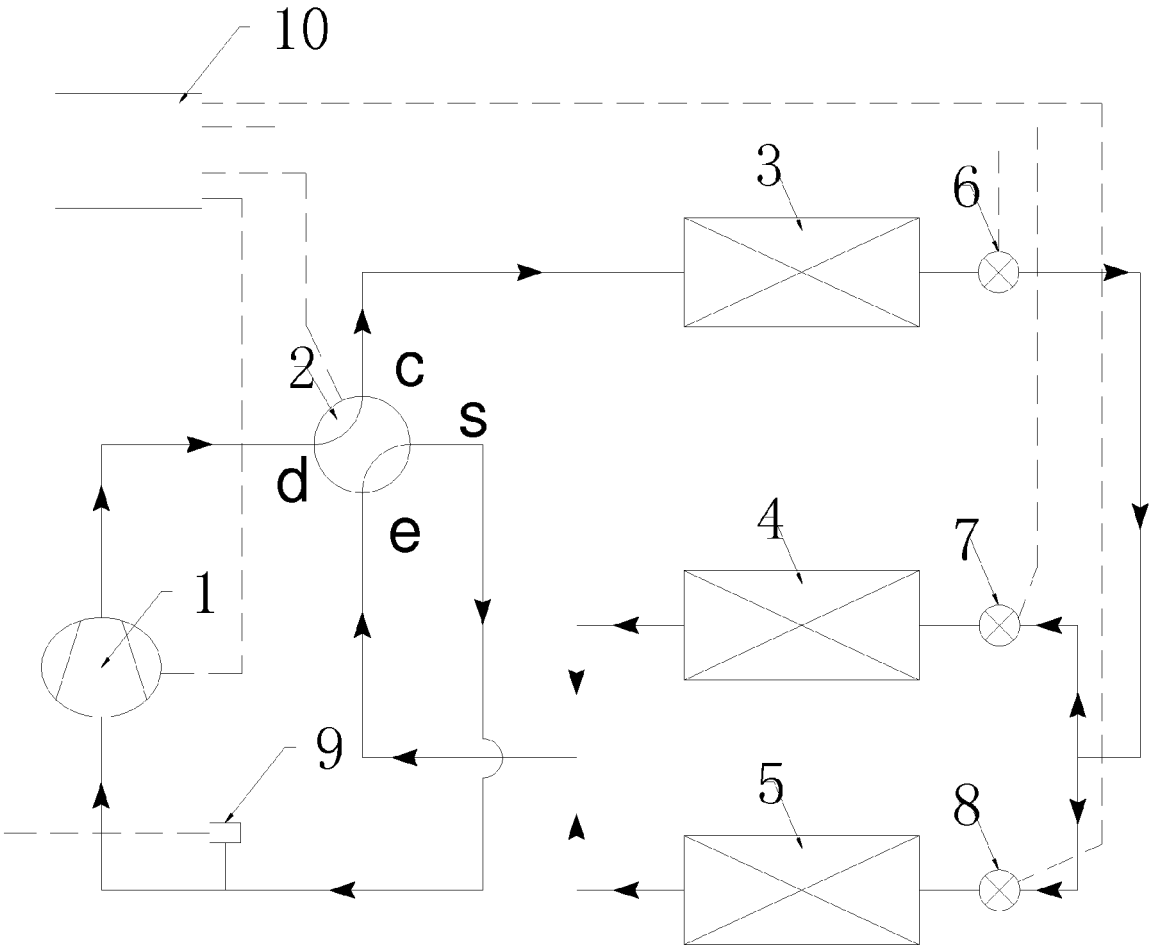

Fig. 3

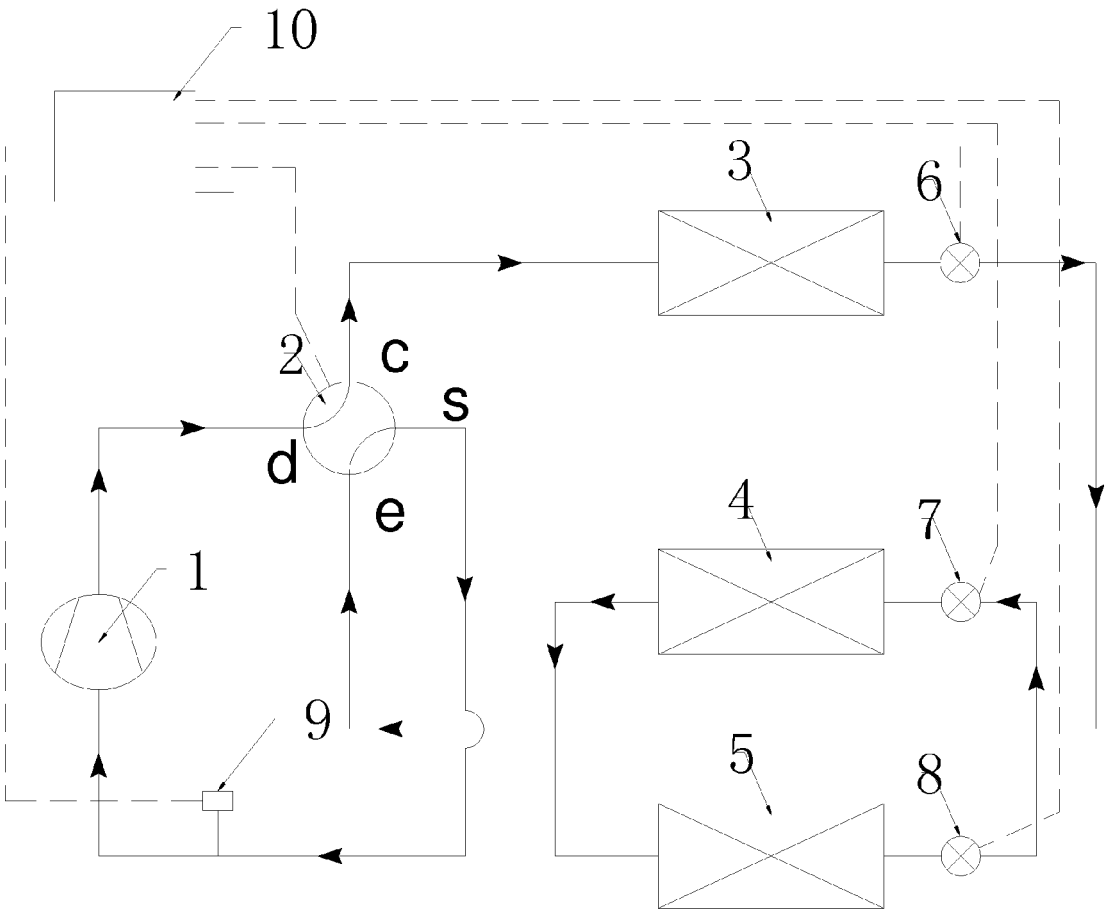

Fig. 4

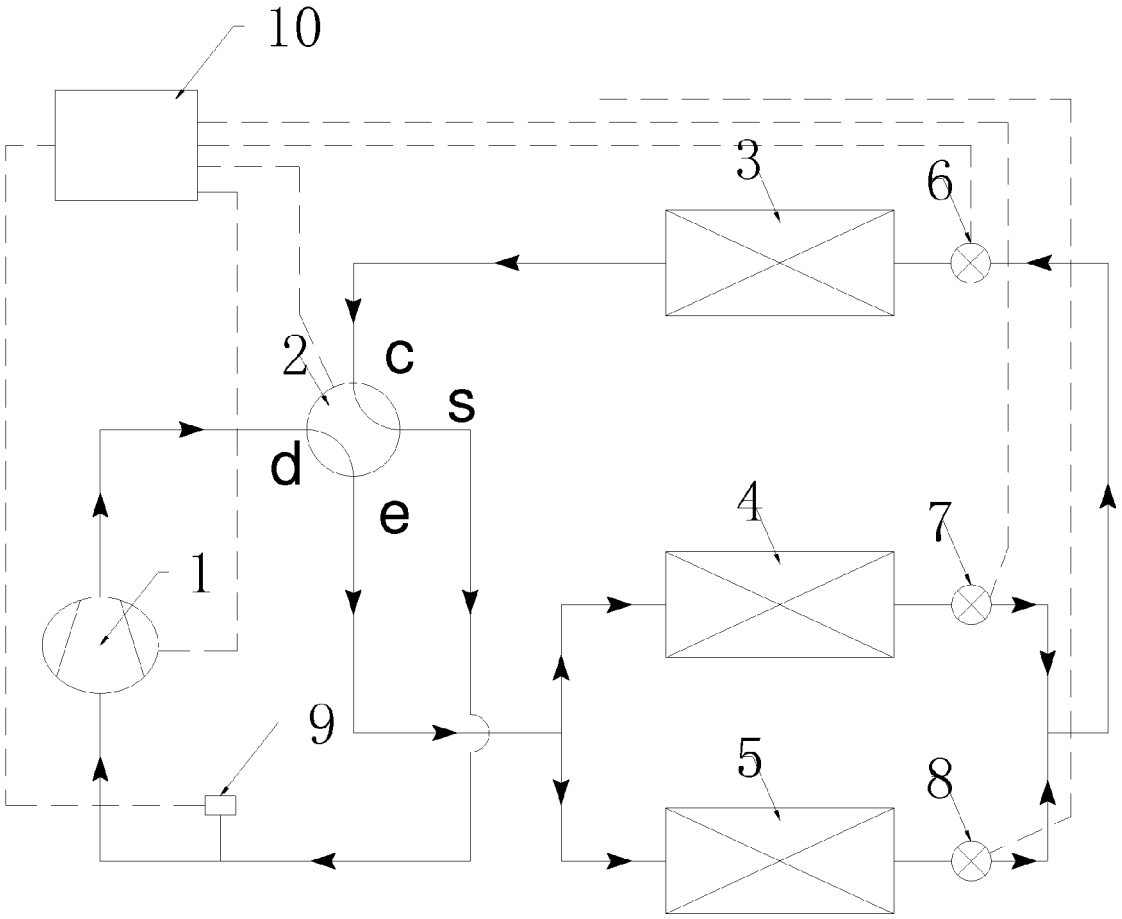

Fig. 5

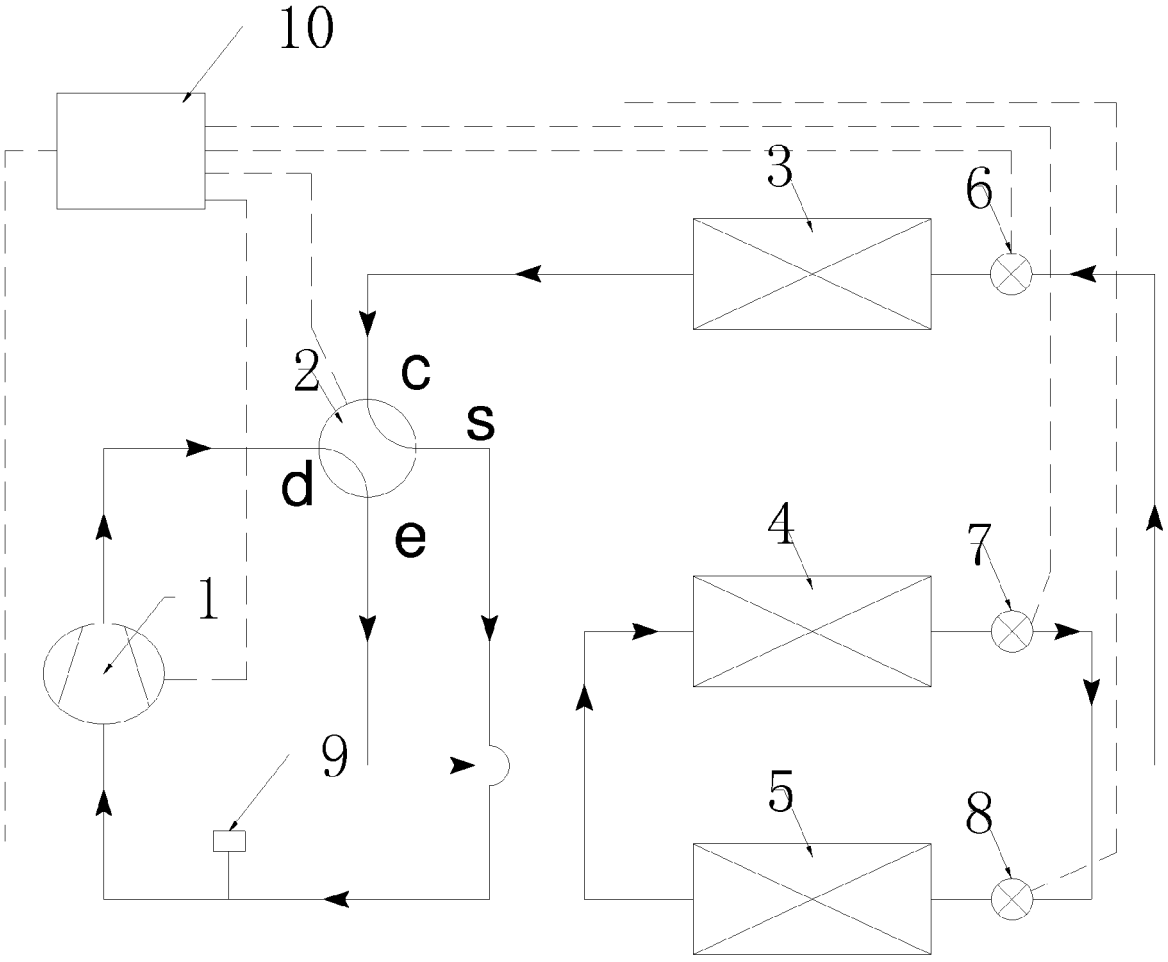

Fig. 6

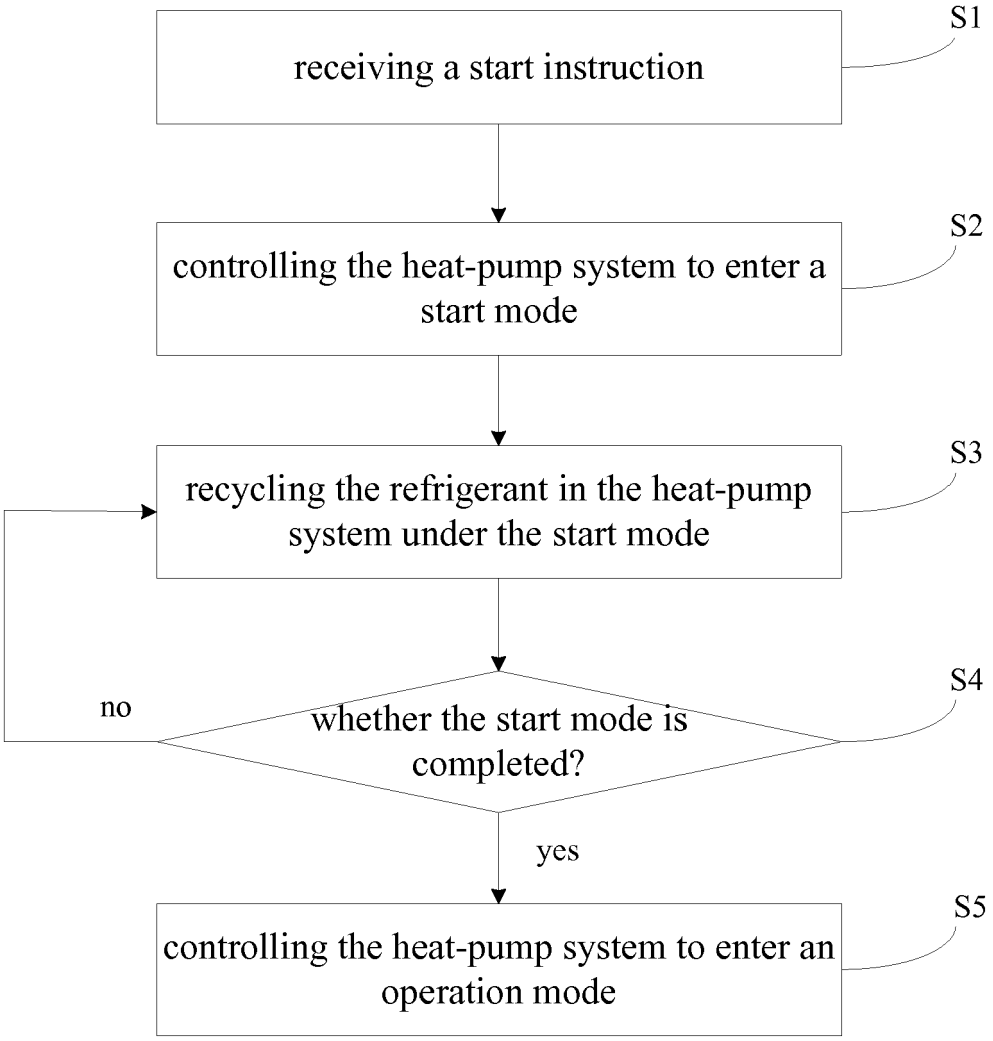
receiving a start instruction
S1
controlling the heat-pump system to enter a start mode
S2
recycling the refrigerant in the heat-pump system under the start mode
S3
whether the start mode is completed?
S4
no
yes
controlling the heat-pump system to enter an operation mode
S5

Fig.7

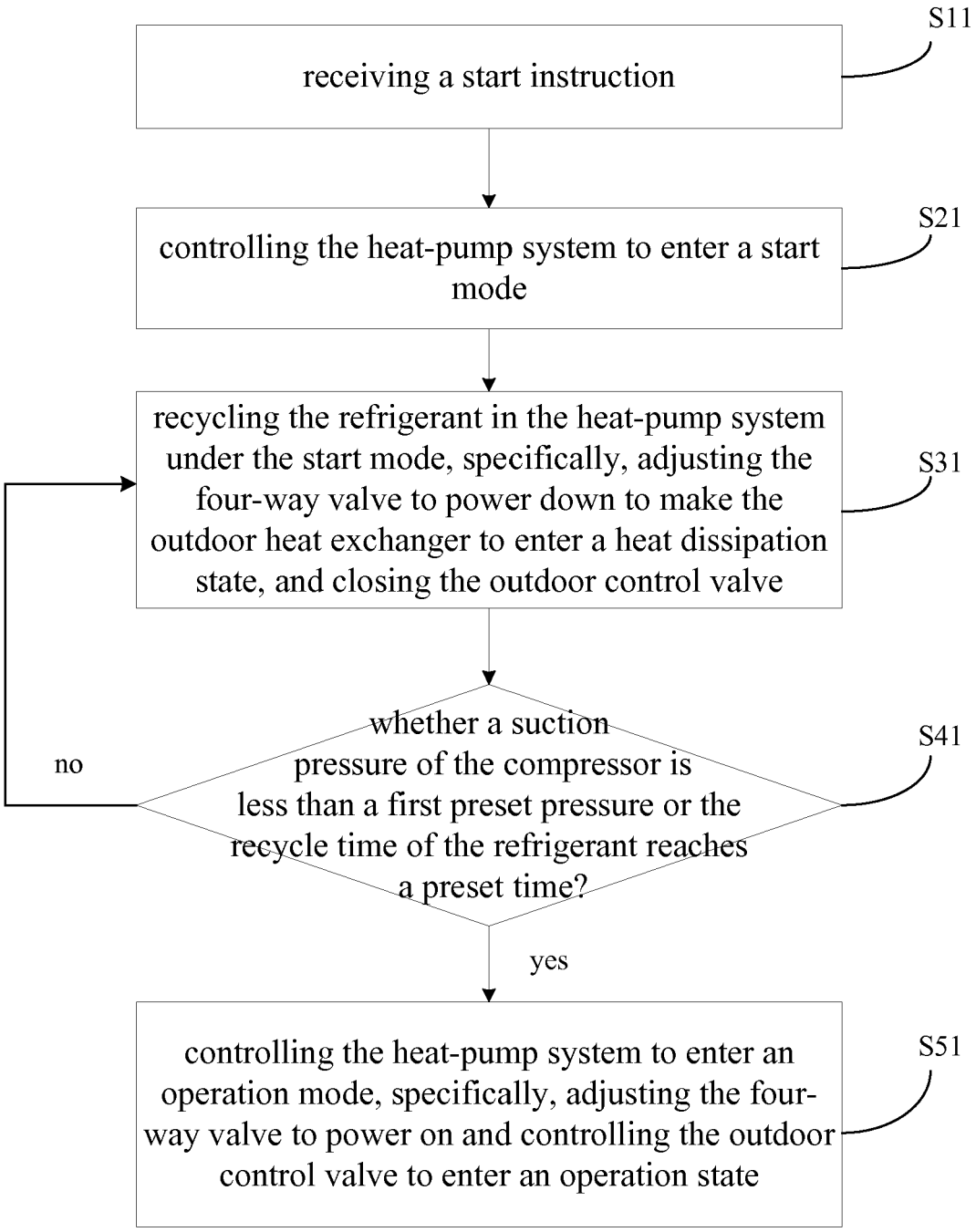
S11
receiving a start instruction
S21
controlling the heat-pump system to enter a start mode
S31
recycling the refrigerant in the heat-pump system under the start mode, specifically, adjusting the four-way valve to power down to make the outdoor heat exchanger to enter a heat dissipation state, and closing the outdoor control valve
S41
whether a suction pressure of the compressor is less than a first preset pressure or the recycle time of the refrigerant reaches a preset time?
no
yes
S51
controlling the heat-pump system to enter an operation mode, specifically, adjusting the four-way valve to power on and controlling the outdoor control valve to enter an operation state

Fig. 8

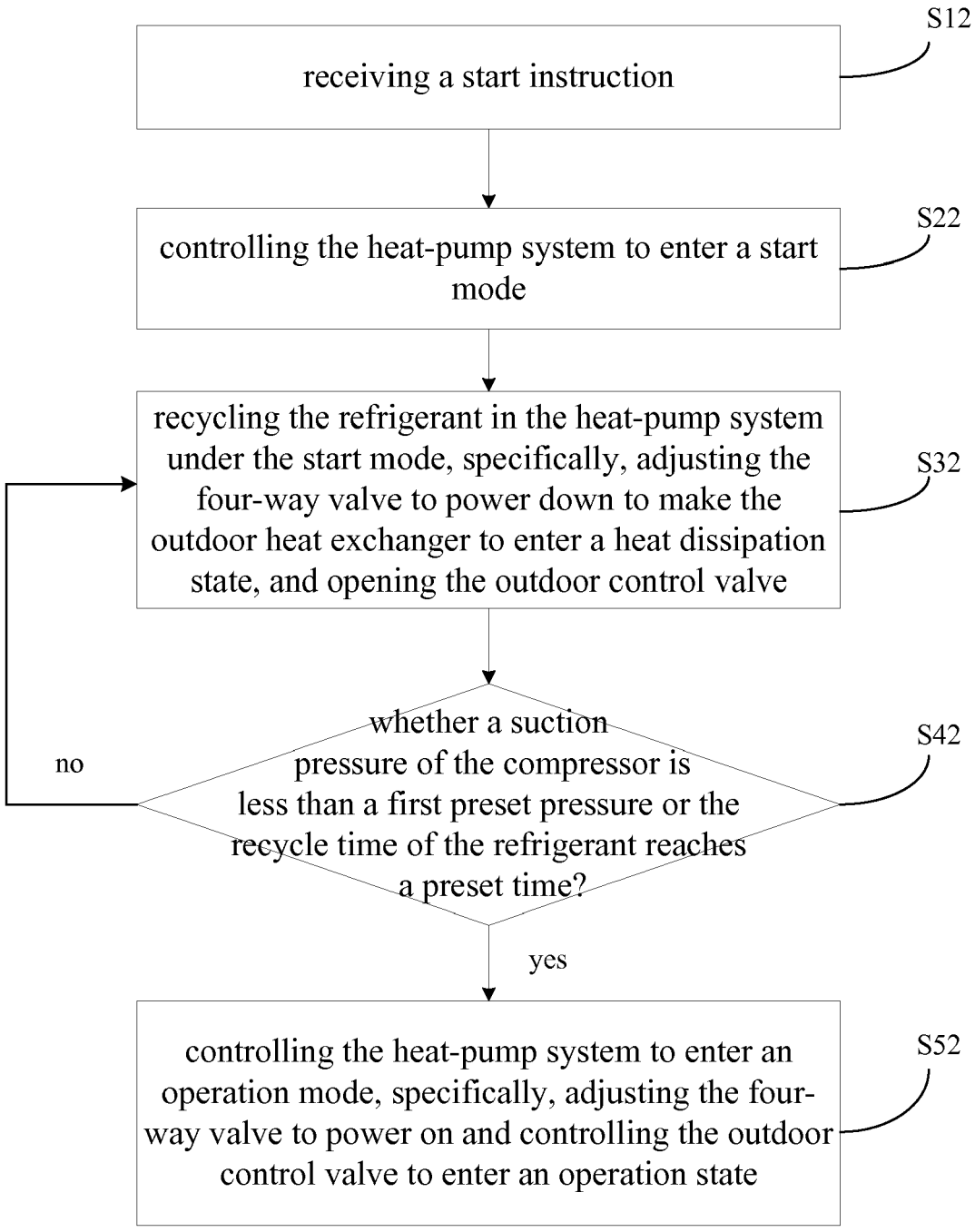
S12
receiving a start instruction
S22
controlling the heat-pump system to enter a start mode
S32
recycling the refrigerant in the heat-pump system under the start mode, specifically, adjusting the four-way valve to power down to make the outdoor heat exchanger to enter a heat dissipation state, and opening the outdoor control valve
S42
whether a suction pressure of the compressor is less than a first preset pressure or the recycle time of the refrigerant reaches a preset time?
no
yes
S52
controlling the heat-pump system to enter an operation mode, specifically, adjusting the four-way valve to power on and controlling the outdoor control valve to enter an operation state

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 6096

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	EP 2 264 379 A1 (DAIKIN IND LTD [JP]) 22 December 2010 (2010-12-22) * paragraphs [0075] - [0086], [0126]; figures 1,3,5 * -----	1-14	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 May 2014	Gasper, Ralf

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