



(11)

EP 4 215 847 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.07.2023 Bulletin 2023/30

(21) Application number: **23153139.3**

(22) Date of filing: **24.01.2023**

(51) International Patent Classification (IPC):
F25B 47/02 (2006.01) **F25B 13/00** (2006.01)
F25B 39/00 (2006.01) **F28D 1/04** (2006.01)
F28D 1/02 (2006.01) **F28D 1/047** (2006.01)

(52) Cooperative Patent Classification (CPC):
F25B 47/025; F25B 13/00; F25B 39/00;
F25B 47/022; F28D 1/024; F28D 1/0408;
F28D 1/0477; F25B 2313/02742

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **24.01.2022 CN 202210079670**

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(54) HEAT PUMP SYSTEM AND CONTROL METHOD THEREOF

(57) The present invention provides a heat pump system (100) and a control method thereof. The heat pump system (100) comprises: a compressor (110); an indoor heat exchanger (120); an outdoor heat exchanger (130) configured as an interlaced heat exchanger having at least two refrigerant flow paths (130a, 130b); a plurality of throttling elements (141, 142, 143); and a first type four-way valve (151) and a second type four-way valve (152); wherein, in a local defrosting mode, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through at least one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141, 142), at least another of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) and the suction port (110a) of the compressor (110). According to the heat pump system (100) and the control method thereof of the present invention, pointing defrosting operations can be performed on some heat exchangers with more severe frosting in outdoor units, which improves the indoor heating comfort during defrosting.

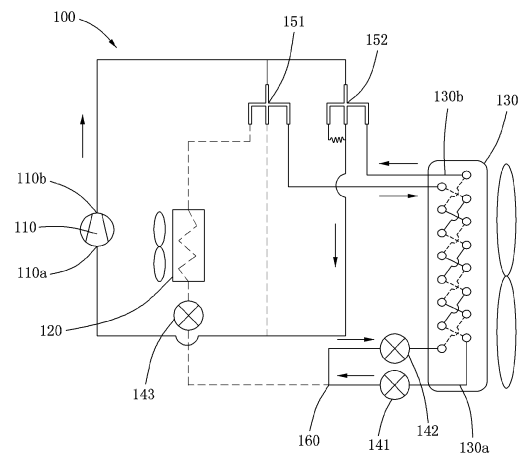


FIG 1

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Description

[0001] The present invention relates to the field of air-conditioning equipment, and in particular to a heat pump system and a control method thereof.

[0002] As a highly mature device, heat pump systems are widely used in commercial buildings, household space and other places, which can provide a relatively comfortable cooling/heating effect. However, engineers in this field are still working to optimize and improve various aspects, one of which is to provide directional defrosting for different locations of the components.

[0003] Defrosting mode is a common function for heat pump systems, which usually functions in winter when heat pump systems are used for heating. At this point, heat exchangers in the outdoor unit already in low temperature environment are still used to absorb heat to evaporate refrigerant in the pipes. Finned pipes on the outside surface of outdoor heat exchangers are prone to frosting in such low temperature and high humidity environments. Therefore, defrosting mode becomes an essential operation, i.e., a reversing operation is performed by switching the flow path switch valve, so that high-temperature gas-phase refrigerant discharged from the compressor flows directly into the outdoor heat exchangers and defrosts through heat dissipation of the high-temperature refrigerant.

[0004] However, defrosting mode of this type is usually performed on all pipes of a condenser. This is suitable for extremely harsh frosting environment. For normal frosting environment, however, different parts of the condenser may be more prone to frosting due to factors such as installation environment and wind direction. Of course, the aforementioned defrosting mode can still accomplish defrosting in this case. However, it can lead to interruption of the heating mode and unnecessary energy loss at the same time.

[0005] In addition, part of the heat in defrosting mode (e.g., about 25%) is lost. For example, a lot of the heat is lost in the air used in heat transfer, and a lot of the heat is lost in heating the metal components of the heat exchangers (e.g., heat-exchange copper tubes or fins).

[0006] The object of the present application is to provide a heat pump system and a control method thereof, so as to at least partially solve or alleviate the problems existing in the prior art.

[0007] According to a first aspect of the present invention, a heat pump system is provided, comprising: a compressor having a suction port and an exhaust port; an indoor heat exchanger having a pipe connection configured to be disconnectable from the heat pump system; an outdoor heat exchanger configured as an interlaced heat exchanger having at least two refrigerant flow paths; a plurality of throttling elements respectively arranged between any two of the indoor heat exchanger and the at least two refrigerant flow paths of the outdoor heat exchanger; and a first type four-way valve and a second type four-way valve, with ports thereof respectively con-

nected to the suction port and the exhaust port of the compressor and one of the at least two refrigerant flow paths of the outdoor heat exchanger; wherein, an unconnected port of the first type four-way valve is connected to the indoor heat exchanger, and an unconnected port of the second type four-way valve is connected to the port connected to the suction port through a capillary or an on-off valve. Wherein, in a local defrosting mode, refrigerant flows sequentially from the exhaust port of the compressor through at least one of the at least two refrigerant flow paths of the outdoor heat exchanger, the throttling element, at least another one of the at least two refrigerant flow paths of the outdoor heat exchanger and the suction port of the compressor.

[0008] Each of the unconnected ports may be termed a remaining port. Equally, each unconnected port may be termed a fourth port with the ports connected to the suction port, the ports connected to the exhaust port of the compressor, and the ports connected to one of the at least two refrigerant flow paths of the outdoor heat exchanger each respectively being termed first, second, and third ports.

[0009] Accordingly, the present invention may be seen to provide a heat pump system comprising: a compressor having a suction port and an exhaust port; an indoor heat exchanger having a pipe connection configured to be disconnectable from the heat pump system; an outdoor heat exchanger configured as an interlaced heat exchanger having at least two refrigerant flow paths; a plurality of throttling elements respectively arranged between any two of the indoor heat exchanger and the at least two refrigerant flow paths of the outdoor heat exchanger; and a first type four-way valve and a second type four-way valve, with ports (i.e. first to third ports) thereof respectively connected to the suction port and the exhaust port of the compressor and one of the at least two refrigerant flow paths of the outdoor heat exchanger; wherein, a remaining (or a fourth) port of the first type four-way valve is connected to the indoor heat exchanger, and a remaining (or a fourth) port of the second type four-way valve is connected to the port connected to the suction port through a capillary or an on-off valve. Wherein, in a local defrosting mode, refrigerant flows sequentially from the exhaust port of the compressor through at least one of the at least two refrigerant flow paths of the outdoor heat exchanger, the throttling element, at least another one of the at least two refrigerant flow paths of the outdoor heat exchanger and the suction port of the compressor.

[0010] In the local defrosting mode, the throttling element may refer to one, some or all of the plurality of throttling elements.

[0011] The plurality of throttling elements may comprise a first throttling element and a second throttling element; a three-way intersection point may be provided on connecting lines between the indoor heat exchanger and the two refrigerant flow paths of the outdoor heat exchanger. Wherein, the first throttling element may be arranged on a first connecting line between the three-

way intersection point and one of the at least two refrigerant flow paths of the outdoor heat exchanger or the indoor heat exchanger; the second throttling element may be arranged on a second connecting line between the three-way intersection point and another one of the at least two refrigerant flow paths of the outdoor heat exchanger or the indoor heat exchanger.

[0012] The first throttling element may be arranged on the first connecting line between the three-way intersection point and one of the at least two refrigerant flow paths of the outdoor heat exchanger; the second throttling element may be arranged on the second connecting line between the three-way intersection point and another one of the at least two refrigerant flow paths of the outdoor heat exchanger.

[0013] The plurality of throttling elements may comprise a first valve at least capable of controlling on-off of the flow path; wherein, the first valve is arranged on a third connecting line between the three-way intersection point and the indoor heat exchanger.

[0014] The first valve may be configured as a third throttling element or a first solenoid valve.

[0015] Optionally, when the first valve is configured as a third throttling element, in a local defrosting mode, refrigerant flows through two of the first throttling element, the second throttling element, and the third throttling element.

[0016] Optionally wherein, in a first local defrosting mode, refrigerant may flow sequentially from the exhaust port of the compressor through at least a first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, at least one of the plurality of throttling elements, at least a second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor. Or, in a second local defrosting mode, refrigerant may flow sequentially from the exhaust port of the compressor through at least the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, at least one of the plurality of throttling elements, at least the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor. Or, in a combined defrosting mode, refrigerant may flow sequentially from the exhaust port of the compressor through at least the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, at least one of the plurality of the throttling elements, at least the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor; and at the same time, refrigerant may flow sequentially from the exhaust port of the compressor through the indoor heat exchanger, at least one of the plurality of the throttling elements, at least the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor.

[0017] In the first local defrosting mode, the at least one of the plurality of throttling elements may comprise

a (the) first throttling element and/or a (the) second throttling element.

[0018] In the second local defrosting mode, the at least one of the plurality of throttling elements may comprise a (the) first throttling element and/or a (the) second throttling element.

[0019] In the combined defrosting mode, for the refrigerant flowing through at least the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, the at least one of the plurality of throttling elements may comprise a (the) first throttling element and/or a (the) second throttling element.

[0020] In the combined defrosting mode, for the refrigerant flowing through the indoor heat exchanger, the at least one of the plurality of throttling elements may comprise a (the) first throttling element and/or a (the) third throttling element.

[0021] The outdoor heat exchanger may comprise a plurality of refrigerant flow paths, and a plurality of the first type four-way valves and/or a plurality of the second type four-way valves may be provided. Wherein, each of the first type four-way valves and/or each of the second type four-way valves may connect to a refrigerant flow path respectively. Wherein, in a local defrosting mode, refrigerant flows sequentially from the exhaust port of the compressor through a part of the plurality of refrigerant flow paths of the outdoor heat exchanger connected to the first type four-way valve or the second type four-way valve, the throttling element (e.g. one, some or all of the plurality of throttling elements), another part of the plurality of refrigerant flow paths of the outdoor heat exchanger connected to the second type four-way valve or the first type four-way valve, and the suction port of the compressor.

[0022] According to a second aspect of the present invention, a control method for the aforementioned heat pump system according to the first aspect of the invention (optionally in accordance with any optional form thereof) is provided, comprising: a first local defrosting mode, in which pipe connections between the first type four-way valve and the second type four-way valve are switched over, so that the exhaust port of the compressor is connected with at least the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger (optionally through a capillary or an on-off valve), at least the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger is connected with the suction port of the compressor, and the pipe connection of the indoor heat exchanger in the heat pump system is disconnected; wherein, refrigerant flows sequentially from the exhaust port of the compressor through the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, at least one of the plurality of throttling elements, the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor; and/or a second local defrosting mode, in which pipe connections between the first type four-way valve and the second type

four-way valve are switched over, so that the exhaust port of the compressor is connected with at least the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, at least the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger is connected with the suction port of the compressor, and the pipe connection of the indoor heat exchanger is disconnected at the same time; wherein, refrigerant flows sequentially from the exhaust port of the compressor through the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, at least one of the plurality of throttling elements, the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor; and/or a combined defrosting mode, in which pipe connections between the first type four-way valve and the second type four-way valve are switched over, so that the exhaust port of the compressor is respectively connected with at least the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger and the indoor heat exchanger, and at least the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger is connected with the suction port of the compressor; wherein, refrigerant flows sequentially from the exhaust port of the compressor through the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, at least one of the plurality of throttling elements, the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor; and at the same time, refrigerant flows sequentially from the exhaust port of the compressor through the indoor heat exchanger, at least one of the plurality of throttling elements, at least the first flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor.

[0023] The control method of the second aspect may include any one or more of all of the optional features described above in respect of the first aspect.

[0024] In the first local defrosting mode, the at least one of the plurality of throttling elements may comprise a (the) first throttling element and/or a (the) second throttling element.

[0025] In the second local defrosting mode, the at least one of the plurality of throttling elements may comprise a (the) first throttling element and/or a (the) second throttling element.

[0026] In the combined defrosting mode, for the refrigerant flowing through at least the second flow path of the at least two refrigerant flow paths of the outdoor heat exchanger, the at least one of the plurality of throttling elements may comprise a (the) first throttling element and/or a (the) second throttling element.

[0027] In the combined defrosting mode, for the refrigerant flowing through the indoor heat exchanger, the at least one of the plurality of throttling elements may comprise a (the) first throttling element and/or a (the) third throttling element.

[0028] The control method may further comprise: a cooling mode or an overall defrosting mode, in which pipe connections between the first type four-way valve and the second type four-way valve are switched over, so that the exhaust port of the compressor is respectively connected with all refrigerant flow paths of the outdoor heat exchanger, and the indoor heat exchanger is connected with the suction port of the compressor; wherein, refrigerant flows sequentially from the exhaust port of the compressor through all refrigerant flow paths of the outdoor heat exchanger, at least one of the plurality of throttling elements, the indoor heat exchanger, and the suction port of the compressor.

[0029] In the cooling mode, the at least one of the throttling elements may comprise a (the) first throttling element, a (the) second throttling element, and a (the) third throttling element.

[0030] The control method may further comprise: a heating mode, in which pipe connections between the first type four-way valve and the second type four-way valve are switched over, so that the exhaust port of the compressor is connected with the indoor heat exchanger, and all refrigerant flow paths of the outdoor heat exchanger are connected with the suction port of the compressor; wherein, refrigerant flows sequentially from the exhaust port of the compressor through the indoor heat exchanger, at least one of the plurality of throttling elements, all refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor.

[0031] In the heating mode, the at least one of the plurality of throttling elements may comprise a (the) first throttling element, a (the) second throttling element, and a (the) third throttling element.

[0032] The heat pump system of the first aspect of the invention and/or the heat pump system controlled by the method of the second aspect may comprise a three-way intersection point on the connecting lines between the indoor heat exchanger and the two refrigerant flow paths of the outdoor heat exchanger, and the heat pump system further comprises a (the) third throttling element or a first solenoid valve capable of controlling the on-off of the flow path, wherein the third throttling element or the first solenoid valve is arranged on a third connecting line between the three-way intersection point and the indoor heat exchanger. Wherein, in a second local defrosting mode, the first solenoid valve is closed and periodically opened; or the third throttling element maintains a minimum opening or is periodically opened.

[0033] The heat pump system according to the present invention, by using an interlaced heat exchanger having at least two refrigerant flow paths as an outdoor heat exchanger and conducting at least one of the refrigerant flow paths, makes it possible for the heat pump system to achieve local defrosting. In addition, through the flow path design of the system, the heating mode can still be maintained in operation at least when the heat pump system is in the local defrosting mode, thus avoiding frequent interruptions of heating mode and improving the user ex-

perience. Furthermore, due to the structural characteristics of the interlaced heat exchanger, the heat losing in the heat transfer air media and heat transfer metal components can be reduced, thus improving the heat utilization efficiency in the defrosting mode. And, coupled with the corresponding control method, the heat pump system can carry out various local defrosting modes. As a result, pointing defrosting can be performed on some heat exchangers with more severe frosting in outdoor units, which also reduces energy loss.

[0034] Certain embodiments of the present invention will now be described in detail hereinafter by way of example only and with reference to the accompanying drawings, in which:

FIG 1 is a schematic diagram of a system flow direction of a heat pump system in a first local defrosting mode.

FIG 2 is a schematic diagram of a system flow direction of the heat pump system in a combined defrosting mode.

FIG 3 is a schematic diagram of a system flow direction of the heat pump system in a cooling mode.

FIG 4 is a schematic diagram of a system flow direction of the heat pump system in a heating mode.

[0035] With reference to FIGS. 1 to 4, different operating modes of a heat pump system are illustrated. Specifically, the flow direction of refrigerant in the current operating mode is shown with arrows in each of the drawings, and the on-off state of the flow path is indicated by solid and dotted lines connected between the components. The flow path configurations of the heat pump system will be described below in conjunction with each of the drawings separately, and then each operating mode will be described in conjunction with each of the drawings separately.

[0036] With continued reference to FIGS. 1 to 4, the heat pump system 100 comprises a compressor 110 having a suction port 110a and an exhaust port 110b, an indoor heat exchanger 120, an outdoor heat exchanger 130, and a throttling element. Wherein, the outdoor heat exchanger 130 is configured as an interlaced heat exchanger with at least two refrigerant flow paths 130a and 130b, and the indoor heat exchanger 120 is configured so that the pipe connection thereof is configured to be disconnectable from the heat pump system. A plurality of throttling elements 141, 142 and 143 are also provided between the indoor heat exchanger 120 and the at least two refrigerant flow paths 130a and 130b of the outdoor heat exchanger 130, respectively, so as to ensure that the refrigerant will be throttled at least once when flowing through any two of them.

[0037] In addition, to achieve the switching function of the heat pump system 100 between various operating

modes, a corresponding flow path switching valve assembly shall also be provided. The flow path switching valve assembly is a first type four-way valve 151 and a second type four-way valve 152. Three ports of the first type four-way valve 151 are respectively connected to the suction port 110a and the exhaust port 110b of the compressor 110, and the first refrigerant flow path 130a of the outdoor heat exchanger 130. Three ports of the second type four-way valve 152 are respectively connected to the suction port 110a and the exhaust port 110b of the compressor 110, and the second refrigerant flow path 130b of the outdoor heat exchanger 130. The unconnected (or remaining) port of the first type four-way valve 151 (the leftmost port of the first type four-way valve 151 in FIG 1) is connected to the indoor heat exchanger 120, while the unconnected (or remaining) port of the second type four-way valve 152 (the leftmost port of the second type four-way valve 152 in FIG 1) is connected to the port connected to the suction port through a capillary or an on-off valve.

[0038] Wherein, the aforementioned interlaced heat exchanger is a mature heat exchanger in the field, which usually has at least two refrigerant inlets and at least two refrigerant outlets corresponding to each other. A plurality of refrigerant branches may be provided between each set of refrigerant inlet and outlet. These refrigerant branches between the same set of refrigerant inlet and outlet jointly constitute a set of refrigerant flow paths mentioned herein. The interlaced heat exchanger may be such that the refrigerant branches in different refrigerant flow paths can be arranged in an interlaced manner. Taking an interlaced heat exchanger with two refrigerant flow paths as an example, several refrigerant branches in the first refrigerant flow path can be arranged close to each other, while the other refrigerant branches thereof can be arranged close to several refrigerant branches in the second refrigerant flow path, so that the refrigerant in the two refrigerant flow paths can exchange heat sufficiently.

[0039] At this point, in a local defrosting mode, the heat pump system can drive the refrigerant to flow sequentially from the exhaust port of the compressor through at least one of the at least two refrigerant flow paths of the outdoor heat exchanger, the throttling element, at least another of the at least two refrigerant flow paths of the outdoor heat exchanger, and the suction port of the compressor.

[0040] The heat pump system, by using an interlaced heat exchanger with at least two refrigerant flow paths as an outdoor heat exchanger and selectively conducting at least one of the refrigerant flow paths, makes it possible for the heat pump system to achieve local defrosting. In addition, through the flow path design of the system, the heating mode can still be maintained in operation at least when the heat pump system is in the local defrosting mode, thus avoiding frequent interruptions of the heating mode and improving the user experience. Furthermore, due to the structural characteristics of the interlaced heat exchanger, the heat loss in the heat transfer air media and heat transfer metal components can be reduced,

thus improving the heat utilization efficiency in the local defrosting mode. It is also possible to perform pointing defrosting operations on some heat exchangers with more severe frosting in outdoor units, which also reduces energy loss. And, this flow path arrangement makes local defrosting mode possible with fewer valves, and at the same time maintains the indoor heating mode in operation in the local defrosting mode, which fully considers the cost-performance balance of the system.

[0041] Various possible modifications of the heat pump system are described below in conjunction with the accompanying drawings. In addition, additional components may be added for further improvement of the energy efficiency or reliability of the system, which are also exemplified below.

[0042] For example, in conjunction with FIGS. 1 to 4, although one four-way valve is used to denote the first type four-way valve 151 and the second type four-way valve 152 mentioned above, it is actually intended to represent two types of four-way valves. These two types of four-way valves have roughly the same connection. The first difference is that one four-way valve has one port connected to the indoor heat exchanger, the other four-way valve has a port connected to the port connected to the suction port 110a through a capillary or an on-off valve. In addition, the second difference is that the two four-way valves are respectively connected to different refrigerant flow paths on the outdoor heat exchanger. Considering that there may be more than two sets of refrigerant flow paths in an interlaced heat exchanger, the first type four-way valve 151 or the second type four-way valve 152 can be respectively configured for the additional sets of refrigerant flow paths, so as to ensure that they can operate according to the flow paths arranged. For example, when the flow path connection scheme is that three second type four-way valves 152 are used to connect the system, the three sets of refrigerant flow paths used in the interlaced heat exchanger have a flow control mode similar to that of the second set of refrigerant flow path 130b. For another example, when the flow path connection scheme is that two first type four-way valves 151 are used to connect the system, the two sets of refrigerant flow paths used in the interlaced heat exchanger have a flow control mode similar to that of the first set of refrigerant flow path 130a. That is, the flow path arrangement of the heat pump system mentioned in the present invention is also applicable to interlaced heat exchangers with multiple sets of refrigerant flow paths, and part of them can be used for local defrosting by corresponding flow path arrangement. Similarly, part of the local defrosting modes can be compatible with indoor heating mode.

[0043] As another example, throttling elements are arranged so that the refrigerant needs to flow between two heat exchangers or two parts of the heat exchanger such that it can undergo expansion throttling, thus achieving the functions of condensation and heat dissipation and evaporation and heat absorption before and after the ex-

pansion throttling, respectively. To this end, one or more throttling element may be provided in the flow path to achieve this purpose.

[0044] With reference to FIGS. 1 to 4, as an example, three throttling elements are provided in the flow path, namely, a first throttling element 141, a second throttling element 142 and a third throttling element 143. When the three-way intersection point 160 on the connecting line between the indoor heat exchanger 120 and the two refrigerant flow paths 130a and 130b of the outdoor heat exchanger 130 is taken as the dividing point, the first throttling element 141 is arranged on the first connecting line between the first refrigerant flow path 130a of the outdoor heat exchanger 130 and the three-way intersection point 160; the second throttling element 142 is arranged on the second connecting line between the second refrigerant flow path 130b of the outdoor heat exchanger 130 and the three-way intersection point 160; the third throttling element 143 is arranged on the third connecting line between the indoor heat exchanger 120 and the three-way intersection point 160. At this point, there are two throttling elements between any two heat exchangers or between any two parts of the heat exchanger. For example, the third throttling element 143 and the first throttling element 141 are sequentially arranged between the indoor heat exchanger 120 and the first refrigerant flow path 130a of the outdoor heat exchanger 130; the third throttling element 143 and the second throttling element 142 are sequentially arranged between the indoor heat exchanger 120 and the second refrigerant flow path 130b of the outdoor heat exchanger 130; and the first throttling element 141 and the second throttling element 142 are sequentially arranged between the first refrigerant flow path 130a and the second refrigerant flow path 130b of the outdoor heat exchanger 130. Under this arrangement, when conducting the corresponding flow path, both the two throttling elements in the flow path can play a throttling role, or only one of them can play a throttling role while the other one is fully opened as a valve for conducting the flow path, thus achieving two throttling effects on any flow path with a larger throttling adjustment range. When a plurality of throttling elements are selected to perform throttling or conducting functions, the throttling element downstream of the flow path where the branch(es) converge should be used for throttling while the throttling element on upstream branch(es) is kept fully open, otherwise system reliability problems may arise.

[0045] In addition, when one of the three throttling elements is used only for conducting the flow path, the valve can also be selected to be a first solenoid valve. For example, under such an arrangement, the third throttling element 143 may be arranged as a first solenoid valve. At this point, the first throttling element 141 and the second throttling element 142 must be arranged on the other two connecting lines in the heat pump system accordingly, so as to ensure that the refrigerant can be throttled at least once when flowing between any two

heat exchangers in each mode.

[0046] As a matter of fact, in accordance with the purpose of arranging the throttling element mentioned above, when any one of the first throttling element 141, the second throttling element 142 and the third throttling element 143 with the aforementioned positions is replaced by a solenoid valve in the system, a throttling element can still be present between any two heat exchangers or two parts of the heat exchanger. That is, the aforementioned heat pump system can also have a usual throttling process in various modes.

[0047] The control method for the heat pump system 100 will be described below in conjunction with FIGS. 1 to 4.

[0048] Referring to FIG 1, a first local defrosting mode of the heat pump system 100 is shown. At this point, the pipe connections between the first type four-way valve 151 and the second type four-way valve 152 can be switched over, so that the exhaust port 110b of the compressor 110 is connected with the first refrigerant flow path 130a of the outdoor heat exchanger 130, the second refrigerant flow path 130b of the outdoor heat exchanger 130 is connected with the suction port 110a of the compressor 110, and the third throttling element 143 is closed so that the refrigerant does not pass through the indoor heat exchanger 120.

[0049] At this point, the refrigerant undergoes gas-phase compression by the compressor 110, flows sequentially from the exhaust port 110b of the compressor 110 through the first type four-way valve 151 to the first refrigerant flow path 130a of the outdoor heat exchanger 130 for condensation and heat dissipation, thus defrosting the refrigerant flow path pipes accordingly. After that, the refrigerant is throttled by one or both of the first throttling element 141 and the second throttling element 142, flows through the second refrigerant flow path 130b of the outdoor heat exchanger 130 for evaporation and heat absorption, and then returns to the suction port 110a of the compressor 110 through the second type four-way valve 152, thus completing the cycle.

[0050] Referring to FIG 2, a combined defrosting mode of the heat pump system 100 is shown. At this point, the pipe connections between the first type four-way valve 151 and the second type four-way valve 152 can be switched over, so that the exhaust port 110b of the compressor 110 is respectively connected with the second refrigerant flow path 130b of the outdoor heat exchanger 130 and the indoor heat exchanger 120, and the first refrigerant flow path 130a of the outdoor heat exchanger 130 is connected with the suction port 110a of the compressor 110.

[0051] At this point, after undergoing gas-phase compression by the compressor 110, a portion of refrigerant flows from the exhaust port 110b of the compressor 110 through the second type four-way valve 152 to the second refrigerant flow path 130b of the outdoor heat exchanger 130 for condensation and heat dissipation, thus defrosting the refrigerant flow path pipes accordingly. After that,

this portion of refrigerant passes through the fully open second throttling element 142, flows through the first throttling element 141 for throttling and then through the first refrigerant flow path 130a of the outdoor heat exchanger 130 for evaporation and heat absorption, and finally returns to the suction port 110a of the compressor 110 through the first type four-way valve 151, thus completing the cycle of this portion of refrigerant. At the same time, another portion of the compressed refrigerant flows from the exhaust port 110b of the compressor 110 through the first type four-way valve 151 to the indoor heat exchanger 120 for condensation and heat dissipation, thus providing heating for indoors accordingly. After that, this portion of refrigerant passes through the fully open third throttling element 143, flows through the first throttling element 141 for throttling and then through the first refrigerant flow path 130a of the outdoor heat exchanger 130 for evaporation and heat absorption, and finally returns to the suction port 110a of the compressor 110 through the first type four-way valve 151, thus completing the cycle of this portion of refrigerant.

[0052] Furthermore, although not shown in the figure, it is also possible to perform only the defrosting function of the combined defrosting mode shown in FIG 2, while no longer performing the heating function thereof. This mode is referred to as a second local defrosting mode. At this point, the pipe connections between the first type four-way valve 151 and the second type four-way valve 152 can be switched over, so that the exhaust port 110b of the compressor 110 is connected with the second refrigerant flow path 130b of the outdoor heat exchanger 130, and the first refrigerant flow path 130a of the outdoor heat exchanger 130 is connected with the suction port 110a of the compressor 110. Meanwhile, the pipe connection of the indoor heat exchanger is disconnected by controlling the third throttling element 143.

[0053] At this point, after undergoing gas-phase compression by the compressor 110, the refrigerant flows from the exhaust port 110b of the compressor 110 through the second type four-way valve 152 to the second refrigerant flow path 130b of the outdoor heat exchanger 130 for condensation and heat dissipation, thus defrosting the refrigerant flow path pipes accordingly. After that, the refrigerant passes through the fully open second throttling element 142, flows through the first throttling element 141 for throttling, and then through the first refrigerant flow path 130a of the outdoor heat exchanger 130 for evaporation and heat absorption, and finally returns to the suction port 110a of the compressor 110 through the first type four-way valve 151, thus completing the refrigerant cycle.

[0054] In the second local defrosting mode, when it is necessary to disconnect the pipe connection of the indoor heat exchanger, if the above third throttling element 143 is taken as an example, the third throttling element may be kept at a minimum opening or kept periodically open for reliability reasons; if the first solenoid valve is taken as an example, it can be closed directly and opened on

periodically. This realizes another local pointing defrosting mode without taking heat from indoors. Although the heating mode of the indoor heat exchanger is no longer in operation at this time, the indoor comfort can be improved to some extent as compared with the conventional defrosting mode which takes heat from indoors.

[0055] Under the above system arrangement, no matter the first local defrosting mode, the second local defrosting mode or the combined defrosting mode, local pointing defrosting can all be achieved without taking heat from indoors, which is advantageous in improving indoor comfort than the conventional defrosting mode which takes heat from indoors. In addition, in the combined defrosting mode, the heating operation of indoor heat exchanger can be maintained while performing defrosting. The flow path arrangement of the system is relatively simple, no additional valves are needed to control the on-off and change of direction of the flow path, and the control logic is simple, so it has good applicability in low-cost occasions.

[0056] Of course, the heat pump system can also achieve the conventional cooling mode, heating mode and overall defrosting mode (i.e., to reverse operating the cooling mode in the heating mode), which will be exemplified below in conjunction with FIGS. 3 and 4.

[0057] Referring to FIG 3, the cooling mode (or overall defrosting mode) of the heat pump system 100 is shown. At this point, the pipe connections between the first type four-way valve 151 and the second type four-way valve 152 can be switched over, so that the exhaust port 110b of the compressor 110 is respectively connected with the first refrigerant flow path 130a and the second refrigerant flow path 130b of the outdoor heat exchanger 130, and the indoor heat exchanger 120 is connected with the suction port 110a of the compressor 110.

[0058] At this point, after undergoing gas-phase compression by the compressor 110, a portion of refrigerant flows from the exhaust port 110b of the compressor 110 through the first type four-way valve 151 to the first refrigerant flow path 130a of the outdoor heat exchanger 130 for condensation and heat dissipation (or in the overall defrosting mode, defrosts the refrigerant flow path pipes accordingly). After that, this portion of refrigerant is throttled by one or both of the first throttling element 141 and the third throttling element 143, flows through the indoor heat exchanger 120 for evaporation and heat absorption and provides cooling for indoors accordingly, and then returns to the suction port 110a of the compressor 110 through the first type four-way valve 151, thus completing the cycle of this portion of refrigerant. At the same time, the other portion of the refrigerant flows from the exhaust port 110b of the compressor 110 through the second type four-way valve 152 to the second refrigerant flow path 130b of the outdoor heat exchanger 130 (or in the overall defrosting mode, defrosts the refrigerant flow path pipes accordingly). After that, this portion of refrigerant is throttled by one or both of the second throttling element 142 and the third throttling element 143, flows

through the indoor heat exchanger 120 for evaporation and heat absorption and provides cooling for indoors accordingly, and then returns to the suction port 110a of the compressor 110 through the first type four-way valve 151, thereby completing the cycle of this portion of refrigerant.

[0059] Referring to FIG 4, the heating mode of the heat pump system 100 is shown. At this point, the pipe connections between the first type four-way valve 151 and the second type four-way valve 152 can be switched over, so that the exhaust port 110b of the compressor 110 is connected with the indoor heat exchanger 120, and the first refrigerant flow path 130a and the second refrigerant flow path 130b of the outdoor heat exchanger 130 are respectively connected with the suction port 110a of the compressor 110.

[0060] At this point, after undergoing gas-phase compression by the compressor 110, the refrigerant flows from the exhaust port 110b of the compressor 110 through the first type four-way valve 151 to the indoor heat exchanger 120 for condensation and heat dissipation. After that, a portion of the refrigerant is throttled by one or both of the third throttling element 143 and the first throttling element 141, flows through the first refrigerant flow path 130a of the outdoor heat exchanger 130 for evaporation and heat absorption, and then returns to the suction port 110a of the compressor 110 through the second type four-way valve 152, thereby completing the cycle of this portion of refrigerant. At the same time, the other portion of the refrigerant is throttled by one or both of the third throttling element 143 and the second throttling element 142, flows through the second refrigerant flow path 130b of the outdoor heat exchanger 130 for evaporation and heat absorption, and then returns to the suction port 110a of the compressor 110 through the first type four-way valve 151, thereby completing the cycle of this portion of refrigerant.

[0061] It should be appreciated that although the embodiments of the control method for the heat pump system is described in a certain order, these steps are not necessarily performed in the order described. Unless explicitly stated herein, there is no strict restriction in terms of the order of carrying out these steps. Instead, these steps can be carried out in other order. In addition, at least one part of the steps of the method may include multiple sub-steps or stages, which may not necessarily be executed at the same time but may be executed at different times, and may not necessarily be executed sequentially but may be executed in turn or alternately with at least one part of the sub-steps or stages of other steps or stages.

[0062] The above examples mainly illustrate a heat pump system and a control method thereof. Although only some of the embodiments of the present invention are described, those skilled in the art should understand that the present invention can, without departing from the scope of the present invention as defined by the appended claims, be implemented in many other forms. There-

fore, the illustrated examples and embodiments are to be considered as illustrative but not restrictive, and the present invention may cover various modifications or replacements if not departed from the scope of the present invention as defined by the appended claims.

Claims

1. A heat pump system (100), comprising:

a compressor (110) having a suction port (110a) and an exhaust port (110b);
 an indoor heat exchanger (120) having a pipe connection configured to be disconnectable from the heat pump system (100);
 an outdoor heat exchanger (130) configured as an interlaced heat exchanger having at least two refrigerant flow paths (130a, 130b);
 a plurality of throttling elements (141, 142, 143) respectively arranged between any two of the indoor heat exchanger (120) and the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130); and
 a first type four-way valve (151) and a second type four-way valve (152), with ports thereof respectively connected to the suction port (110a) and the exhaust port (110b) of the compressor (110) and one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130); wherein, an unconnected port of the first type four-way valve (151) is connected to the indoor heat exchanger (120), and an unconnected port of the second type four-way valve (152) is connected to the port connected to the suction port through a capillary or an on-off valve;
 wherein, in a local defrosting mode, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through at least one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141, 142, 143), at least another one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) and the suction port (110a) of the compressor (110).

2. The heat pump system (100) according to claim 1, wherein the plurality of throttling element (141, 142, 143) comprise a first throttling element (141) and a second throttling element (142); a three-way intersection point (160) is provided on connecting lines between the indoor heat exchanger (120) and the two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), wherein, the first throttling element (141) is arranged on a first connecting line between the three-way intersection point (160) and

one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) or the indoor heat exchanger (120); and the second throttling element (142) is arranged on a second connecting line between the three-way intersection point (160) and another one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) or the indoor heat exchanger (120).

3. The heat pump system (100) according to claim 2, wherein the first throttling element (141) is arranged on the first connecting line between the three-way intersection point (160) and one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130); the second throttling element (142) is arranged on the second connecting line between the three-way intersection point (160) and another one of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130).

4. The heat pump system (100) according to claim 3, wherein the plurality of throttling element (141, 142, 143) further comprise a first valve at least capable of controlling on-off of the flow path; wherein, the first valve is arranged on a third connecting line between the three-way intersection point (160) and the indoor heat exchanger (120).

5. The heat pump system (100) according to claim 4, wherein the first valve is configured as a third throttling element (143) or a first solenoid valve.

6. The heat pump system (100) according to claim 5, wherein when the first valve is configured as a third throttling element (143), in the local defrosting mode, refrigerant flows through two of the first throttling element (141), the second throttling element (142) and the third throttling element (143).

7. The heat pump system (100) according to any of claims 1 to 6, wherein:

in a first local defrosting mode, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through at least a first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141, 142, 143), at least a second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110); or
 in a second local defrosting mode, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through at least the second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141,

- 142, 143), at least the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110); or
 5 in a combined defrosting mode, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through at least the second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141, 142, 143), at least the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110); and at the same time, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through the indoor heat exchanger (120), the throttling element (141, 142, 143), at least the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110).
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8. The heat pump system (100) according to any of claims 1 to 7, wherein, the outdoor heat exchanger (130) is configured to comprise a plurality of refrigerant flow paths (130a, 130b), and a plurality of the first type four-way valves (151) and/or the second type four-way valves (152) are provided; wherein, each of the first type four-way valves (151) and/or each of the second type four-way valves (152) connect to a refrigerant flow path (130a, 130b) respectively; wherein, in the local defrosting mode, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through a part of the plurality of refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) connected to the first type four-way valve (151) or the second type four-way valve (152), the throttling element (141, 142, 143), another part of the plurality of refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) connected to the second type four-way valve (152) or the first type four-way valve (151), and the suction port (110a) of the compressor (110).
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9. A control method for the heat pump system (100) according to any of claims 1 to 8, comprising:
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- a first local defrosting mode, in which pipe connections between the first type four-way valve (151) and the second type four-way valve (152) are switched over, so that the exhaust port (110b) of the compressor (110) is connected with at least the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), at least the

second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) is connected with the suction port (110a) of the compressor (110), and the pipe connection of the indoor heat exchanger (120) in the heat pump system (100) is disconnected; wherein, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141, 142, 143), the second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110); and/or
 a second local defrosting mode, in which pipe connections between the first type four-way valve (151) and the second type four-way valve (152) are switched over, so that the exhaust port (110b) of the compressor (110) is connected with at least the second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and at least the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) is connected with the suction port (110a) of the compressor (110), and the pipe connection of the indoor heat exchanger (120) is disconnected at the same time; wherein, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through the second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141, 142, 143), the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110); and/or
 a combined defrosting mode, in which pipe connections between the first type four-way valve (151) and the second type four-way valve (151) are switched over, so that the exhaust port (110b) of the compressor (110) is respectively connected with at least the second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) and the indoor heat exchanger (120), and at least the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) is connected with the suction port (110a) of the compressor (110); wherein, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through the second flow path (130b) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling

element (141, 142, 143), the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110); and at the same time, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through the indoor heat exchanger (120), the throttling element (141, 142, 143), at least the first flow path (130a) of the at least two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110).

heat exchanger (120); wherein, in the second local defrosting mode, the first solenoid valve is closed and periodically opened; or the third throttling element (143) maintains a minimum opening or is periodically opened.

10. The control method according to claim 9, further comprising: a cooling mode or an overall defrosting mode, in which pipe connections between the first type four-way valve (151) and the second type four-way valve (152) are switched over, so that the exhaust port (110b) of the compressor (110) is respectively connected with all refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the indoor heat exchanger (120) is connected with the suction port (110a) of the compressor (110); wherein, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through all refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), the throttling element (141, 142, 143), the indoor heat exchanger (120), and the suction port (110a) of the compressor (110).
11. The control method according to claim 9 or 10, further comprising: a heating mode, in which pipe connections between the first type four-way valve (151) and the second type four-way valve (152) are switched over, so that the exhaust port (110b) of the compressor (110) is connected with the indoor heat exchanger (120), and all refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130) are connected with the suction port (110a) of the compressor (110); wherein, refrigerant flows sequentially from the exhaust port (110b) of the compressor (110) through the indoor heat exchanger (120), the throttling element (141, 142, 143), all refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the suction port (110a) of the compressor (110).
12. The control method according to claim 9, 10 or 11, wherein, the heat pump system (100) comprises a three-way intersection point (160) on the connecting lines between the indoor heat exchanger (120) and the two refrigerant flow paths (130a, 130b) of the outdoor heat exchanger (130), and the heat pump system (100) further comprises a third throttling element (143) or a first solenoid valve capable of controlling the on-off of the flow path, wherein the third throttling element (143) or the first solenoid valve is arranged on a third connecting line between the three-way intersection point (160) and the indoor

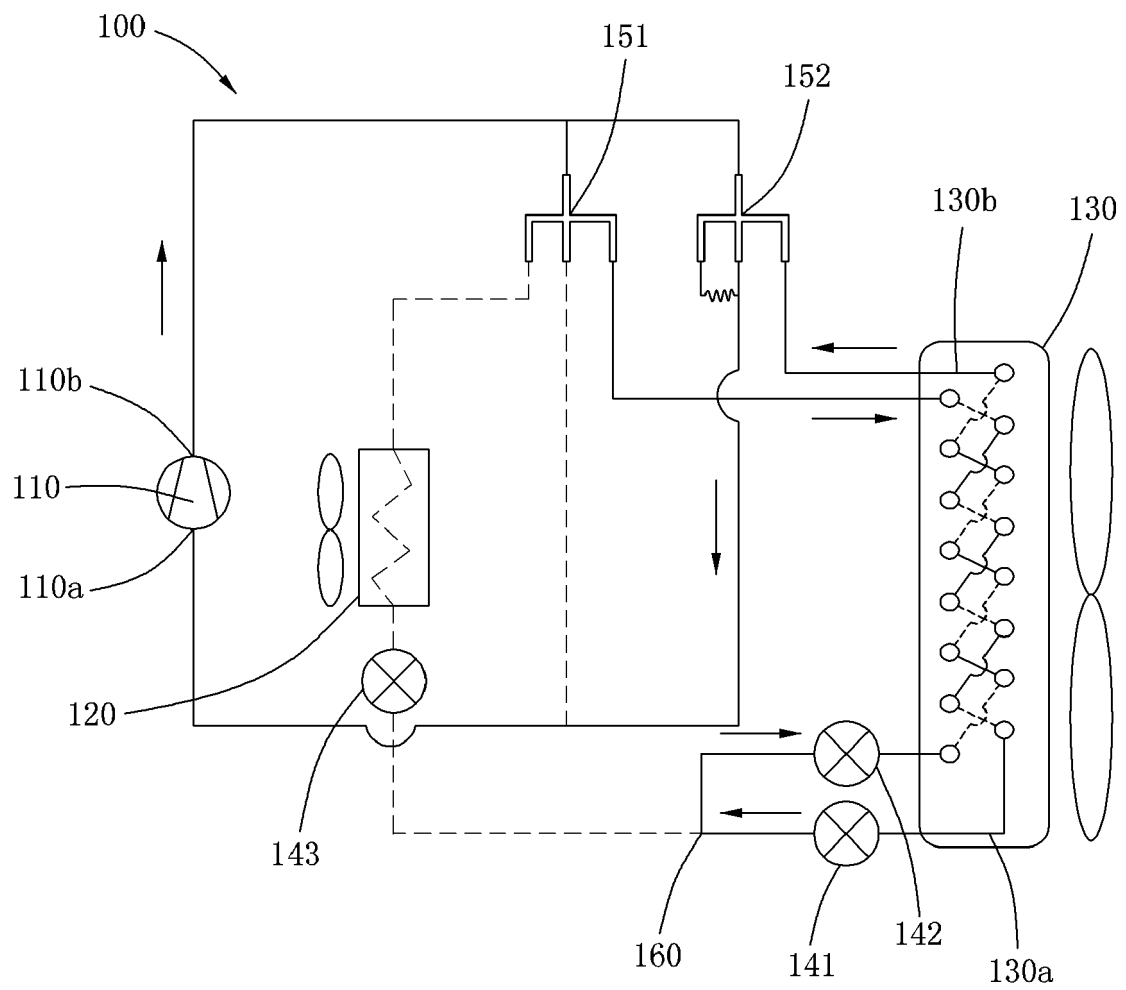


FIG 1

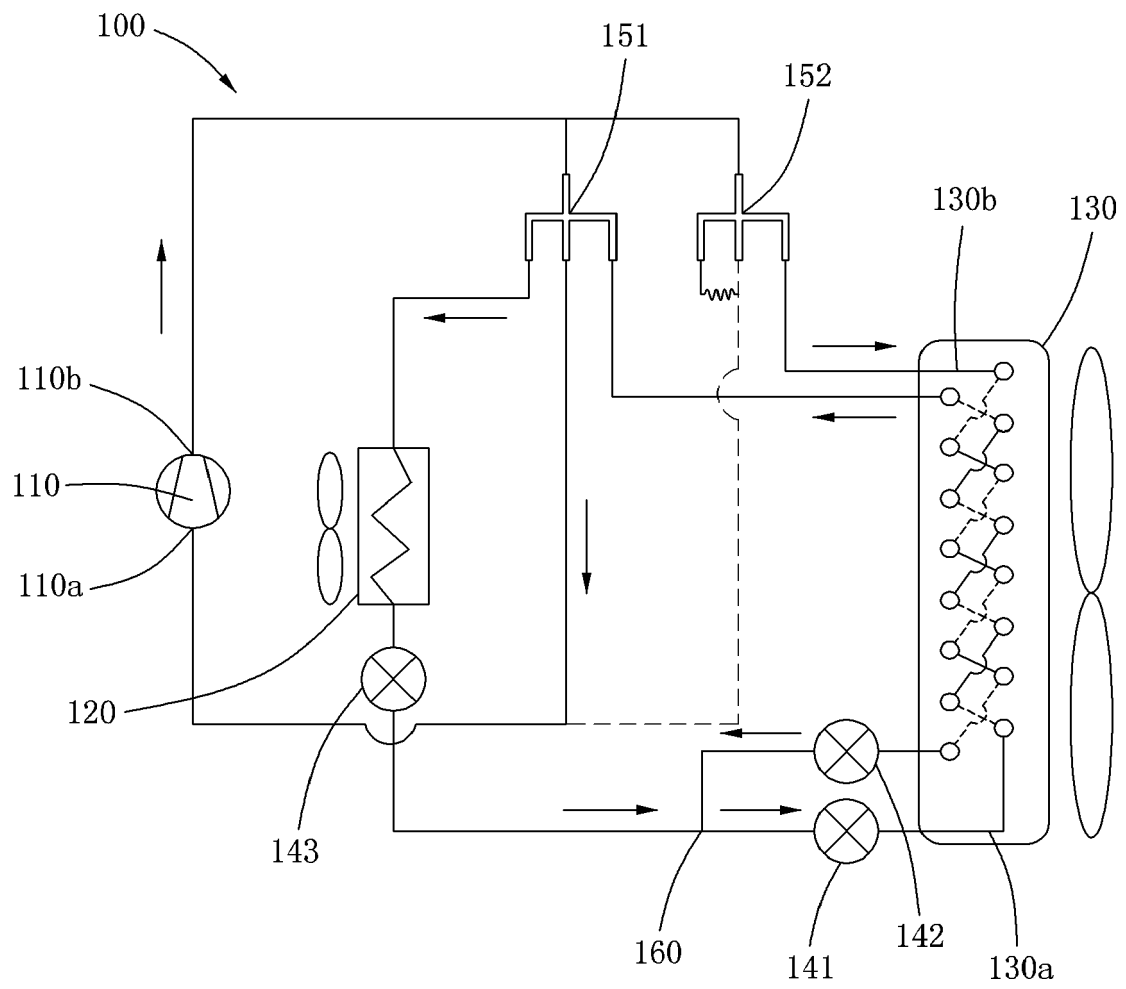


FIG 2

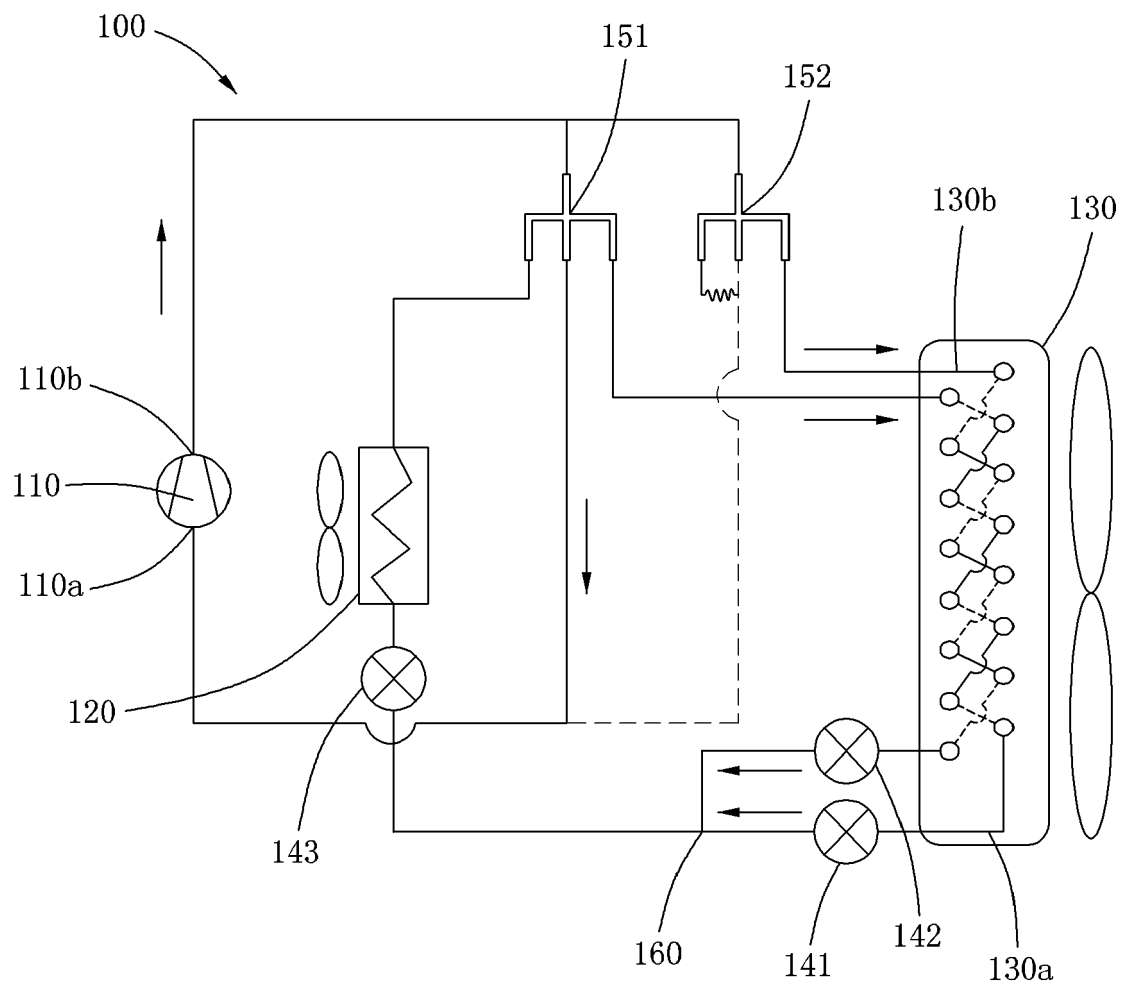


FIG 3

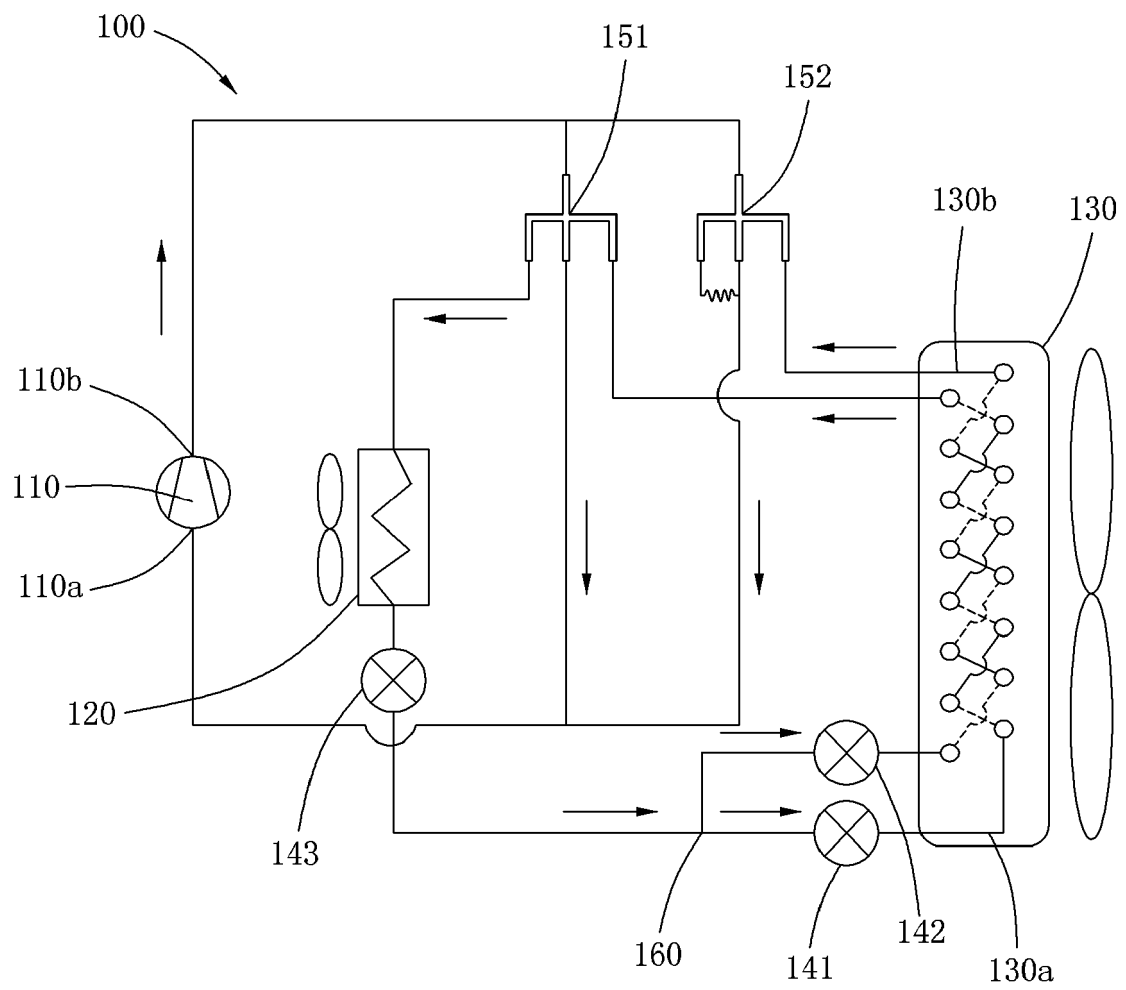


FIG 4



EUROPEAN SEARCH REPORT

Application Number

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			F25B F28D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 May 2023	Examiner Amous, Moez
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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