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(54) **ANTI-SLUGGING CONTROL METHOD AND CONTROL APPARATUS FOR AIR-CONDITIONING SYSTEM, AND AIR-CONDITIONING SYSTEM**

(57) An anti-slugging control method and control apparatus for an air-conditioning system and an air-conditioning system. The control method comprises the following steps: obtaining a discharge superheat DSH of a compressor in real time, and monitoring the discharge superheat DSH during operation of the air-conditioning system (S10); controlling a timer to start timing if the discharge superheat DSH is less than a first preset value M1 continuously for a first preset time t1 (S20); and controlling an outdoor unit of the air-conditioning system to stop to prevent slugging from occurring in the compressor when a measured time t of the timer reaches a second preset time t2 (S30). The discharge superheat DSH in

the air-conditioning system is monitored in real time, such that a refrigerant drawn back to an air return port of the compressor can be ensured to be in a completely gaseous state, thereby preventing a liquid refrigerant from entering the compressor and preventing slugging. In addition, because a value of the discharge superheat is relatively large, it is convenient to inspect and control data, thereby improving the precision of anti-slugging control, and operating safety and reliability of the air-conditioning system.

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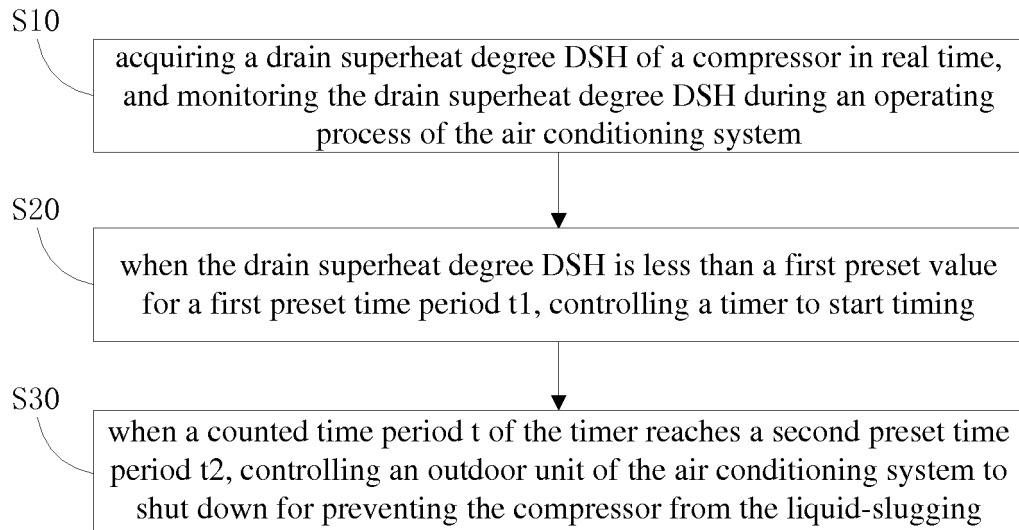


Fig. 1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priorities to Chinese Patent Application No. 201611027983.3 and Chinese Patent Application No. 201611034105.4, both filed with the State Intellectual Property Office of P. R. China on November 17, 2016, the entire content of which are incorporated herein by reference.

FIELD

[0002] The present disclosure relates to the field of air conditioner technology, and more particularly to a control method of anti-liquid-slugging of air conditioning system and a control device of anti-liquid-slugging of air conditioning system, and an air conditioning system.

BACKGROUND

[0003] In an air conditioning system, several factors, such as too much refrigerant or lubricating oil, excessive adjustment degree (opening degree) of expansion valve (or adjusting valve), instability of thermal load of an evaporator and the like, may cause that liquid refrigerant enters into an air cylinder of a compressor, such that the compressor is suffered from liquid-slugging. As a result, long-time and heavy liquid-slugging may cause a valve plate of the compressor deformed, broken or even cause the compressor permanently damaged.

[0004] In related arts, in order to ensure that the refrigerant sucked back through an air inlet of the compressor is gaseous, suction superheat degree of the air conditioning system is general monitored in real time, thereby preventing that the liquid refrigerant enters into the compressor and avoiding that the compressor is suffered from the liquid-slugging. However, generally the value of the suction superheat degree of the air conditioning system is relatively small, which is not easy to be detected and controlled. Therefore, an accuracy of anti-liquid-slugging control of the compressor is relatively low and reliability is poor.

[0005] Therefore, there is a need to improve the control method for preventing the compressor from the liquid-slugging in the related arts.

SUMMARY

[0006] Embodiments of the present disclosure seek to solve at least one of the problems existing in the related art to at least some extent.

[0007] In order to achieve above objectives, embodiments of a first aspect of the present disclosure provide a control method of anti-liquid-slugging of air conditioning system. The control method includes acquiring a drain superheat degree of a compressor in real time, monitoring the drain superheat degree during an operating proc-

ess of the air conditioning system; when the drain superheat degree is less than a first preset value for a first preset time period, controlling a timer to start timing; and when a counted time period of the timer reaches a second preset time period, controlling an outdoor unit of the air conditioning system to shut down for preventing the compressor from the liquid-slugging.

[0008] In at least one embodiment, during a timing process of the timer, when the drain superheat degree is greater than or equal to the first preset value for a third preset time period, resetting the timer and continuing to determine whether the drain superheat degree satisfies a condition that the timer starts timing.

[0009] In at least one embodiment, after controlling the outdoor unit to shut down, the control method further includes determining whether a number of anti-liquid-slugging protection activated by the air conditioning system during a fourth preset time period exceeds a preset number, while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period exceeds the preset number, controlling the outdoor unit to be unrecoverable without being powered off; and while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period does not exceed the preset number, resetting the timer, and controlling the outdoor unit to restart after a fifth preset time period.

[0010] In at least one embodiment, the air conditioning system includes the compressor, a condenser and an evaporator, and acquiring the drain superheat degree of the compressor in real time includes: detecting temperature of an air outlet of the compressor, and detecting temperature of a middle part of the condenser and temperature of a middle part of the evaporator; when the air conditioning system is in a refrigerating mode, calculating the drain superheat degree of the compressor according to the temperature of the air outlet and the temperature of the middle part of the condenser; and when the air conditioning system is in a heating mode, calculating the drain superheat degree of the compressor according to the temperature of the air outlet and the temperature of the middle part of the evaporator.

[0011] In at least one embodiment, acquiring the drain superheat degree of the compressor in real time includes: detecting a pressure of an air outlet of the compressor and detecting temperature of the air outlet of the compressor; and calculating the drain superheat degree of the compressor according to the pressure of the air outlet and the temperature of the air outlet.

[0012] In at least one embodiment, the first preset time period may be 20 minutes, the second preset time period may be 30 minutes, the third preset time period may be 5 minutes, the fourth preset time period may be 120 minutes and the fifth preset time period may be 6 minutes.

[0013] With the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure, by acquiring the drain superheat

degree of the compressor in real time, and by monitoring the drain superheat degree during the operating process of the air conditioning system, the timer is controlled to start timing when the drain superheat degree is less than the first preset value for the first preset time period; and the outdoor unit of the air conditioning system is controlled to shut down for preventing the compressor from the liquid-slugging when the counted time period of the timer reaches the second preset time period. Therefore, the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may realize anti-liquid-slugging protection by monitoring the drain superheat degree of the compressor in real time, such that it may be ensured that refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0014] In order to achieve above objectives, embodiments of a second aspect of the present disclosure provide a non-transitory computer readable storage medium, having computer programs stored thereon. When the computer programs are executed by a processor, the control method of anti-liquid-slugging of air conditioning system according to embodiments of the first aspect is realized.

[0015] In order to achieve above objectives, embodiments of a third aspect of the present disclosure provide a control device of anti-liquid-slugging of air conditioning system. The control device includes: an acquiring module, configured to acquire a drain superheat degree of a compressor in real time; a monitoring module, configured to monitor the drain superheat degree during an operating process of the air conditioning system; and a control module, configured to, when the drain superheat degree is less than a first preset value for a first preset time period, control a timer to start timing; and when a counted time period of the timer reaches a second preset time period, control an outdoor unit of the air conditioning system to shut down for preventing the compressor from the liquid-slugging.

[0016] In at least one embodiment, during a timing process of the timer, when the drain superheat degree is greater than or equal to the first preset value for a third preset time period, the control module is configured to reset the timer and continue to determine whether the drain superheat degree satisfies a condition that the timer starts timing.

[0017] In at least one embodiment, after the outdoor unit is controlled to shut down, the control module is further configured to determine, whether a number of anti-liquid-slugging protection activated by the air conditioning system during a fourth preset time period exceeds a

preset number, while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period exceeds the preset number, the control module is configured to control the outdoor unit to be unrecoverable without being powered off; and while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period does not exceed the preset number, the control module is configured to reset the timer, and control the outdoor unit to restart after a fifth preset time period.

[0018] In at least one embodiment, the air conditioning system includes the compressor, a condenser and an evaporator, and the control device further includes: a first temperature sensor arranged at an air outlet of the compressor and configured to detect temperature of the air outlet of the compressor; a second temperature sensor arranged at a middle part of the condenser and configured to detect temperature of the middle part of the condenser; and a third temperature sensor arranged at a middle part of the evaporator and configured to detect temperature of the middle part of the evaporator; the acquiring module is further configured to calculate the drain superheat degree of the compressor according to the temperature of the air outlet and the temperature of the middle part of the condenser when the air conditioning system is in a refrigerating mode; and to calculate the drain superheat degree of the compressor according to the temperature of the air outlet and the temperature of the middle part of the evaporator when the air conditioning system is in a heating mode.

[0019] In at least one embodiment, the control device further includes a temperature sensor and a pressure sensor arranged at an air outlet of the compressor, the temperature sensor is configured to detect temperature of the air outlet of the compressor and the pressure sensor is configured to detect pressure of the air outlet of the compressor, and the acquiring module is configured to calculate the drain superheat degree of the compressor according to the temperature of the air outlet and the pressure of the air outlet.

[0020] In at least one embodiment, the first preset time period may be 20 minutes, the second preset time period may be 30 minutes, the third preset time period may be 5 minutes, the fourth preset time period may be 120 minutes and the fifth preset time period may be 6 minutes.

[0021] With the control device of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure, by acquiring the drain superheat degree of the compressor in real time with the acquiring module, and by monitoring the drain superheat degree with the monitoring module during the operating process of the air conditioning system, the control module is configured to control the timer to start timing when the drain superheat degree is less than the first preset value for the first preset time period; and the control module is configured to control the outdoor unit of the air conditioning system to shut down for preventing the compressor

from the liquid-slugging when the counted time period of the timer reaches the second preset time period. Therefore, the control device of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may realize anti-liquid-slugging protection by monitoring the drain superheat degree of the compressor in real time, such that it may be ensured that refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of the anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0022] In order to achieve above objectives, embodiments of a fourth aspect of the present disclosure provide an air conditioning system. The air conditioning system includes the control device of anti-liquid-slugging of air conditioning system according to above embodiments.

[0023] With the air conditioning system according to embodiments of the present disclosure, an anti-liquid-slugging protection is realized by monitoring the drain superheat degree of the compressor in real time with the above control device of anti-liquid-slugging of air conditioning system, such that it may be ensured that refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0024] Additional aspects and advantages of embodiments of present disclosure will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

Fig. 1 is a flow chart illustrating a control method of anti-liquid-slugging of air conditioning system according to an embodiment of the present disclosure; Fig. 2 is a diagram illustrating a pressure vs enthalpy curve of an air conditioning system according to an embodiment of the present disclosure;

Fig. 3 is a flow chart illustrating a control method of anti-liquid-slugging of air conditioning system according to another embodiment of the present disclosure;

Fig. 4 is a flow chart illustrating a control method of

anti-liquid-slugging of air conditioning system according to a specific embodiment of the present disclosure; Fig. 5 is a block diagram illustrating a control device of anti-liquid-slugging of air conditioning system according to an embodiment of the present disclosure;

Fig. 6 is a schematic diagram illustrating an air conditioning system according to an embodiment of the present disclosure;

Fig. 7 is a block diagram illustrating a control device of anti-liquid-slugging of air conditioning system according to another embodiment of the present disclosure;

Fig. 8 is a schematic diagram illustrating an air conditioning system according to another embodiment of the present disclosure; and

Fig. 9 is a block diagram illustrating an air conditioning system according to embodiments of the present disclosure.

[0026] Reference numerals:

acquiring module 10, monitoring module 20, control module 30, fourth temperature sensor 40, pressure sensor 50, and timer 60;

first temperature sensor 70, second temperature sensor 80, third temperature sensor 90, calculating module 11;

compressor 100, evaporator 200, condenser 300, air conditioning system 400, and control device 500 of anti-liquid-slugging of air conditioning system.

DETAILED DESCRIPTION

[0027] Descriptions will be made in detail to embodiments of the present disclosure, examples of the embodiments are shown in drawings, in which the same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions. The embodiments described herein with reference to drawings are explanatory, are intended to understand the present disclosure, and are not construed to limit the present disclosure.

[0028] A control method of anti-liquid-slugging of air conditioning system and a control device of anti-liquid-slugging of air conditioning system and an air conditioning system provided in embodiments of the present disclosure will be described with reference to drawings.

[0029] Fig. 1 is a flow chart illustrating a control method of anti-liquid-slugging of air conditioning system according to an embodiment of the present disclosure. As illustrated in Fig. 1, the control method of anti-liquid-slugging of air conditioning system includes the followings.

[0030] In block S10, drain superheat degree DSH of a compressor is acquired in real time, and the drain superheat degree DSH is monitored during an operating process of an air conditioning system.

[0031] According to an embodiment of the present dis-

closure, acquiring the drain superheat degree DSH of the compressor in real time includes the following. Pressure P of an air outlet of the compressor is detected, and temperature Tc of the air outlet of the compressor is detected. The drain superheat degree DSH of the compressor is calculated according to the pressure P of the air outlet and the temperature Tc of the air outlet.

[0032] Specifically, based on analysis of the operating process of the air conditioning system, a pressure vs enthalpy diagram illustrated in Fig. 2 may be obtained. In the diagram, a longitudinal coordinate represents a logarithm value LogP of an absolute pressure of the air conditioning system, while a horizontal coordinate represents a specific enthalpy value b of the air conditioning system. As illustrated in Fig. 2, the air conditioning system is in a superheat and exothermic phase indicated by segments 1-2, where gaseous refrigerant with high temperature and high pressure is exhausted from the air outlet of the compressor. The air conditioning system is in a constant pressure and exothermic phase indicated by segments 2-4. The air conditioning system is in a constant pressure and endothermic phase indicated by segments 5-6. The air conditioning system is in a superheat and endothermic phase indicated by segments 6-7, where the refrigerant is sucked back through an air inlet of the compressor. As illustrated in Fig. 2, the drain superheat degree DSH of the air conditioning system corresponds to the suction superheat degree SSH, and the value of the drain superheat degree DSH is greater than the value of the suction superheat degree SSH. Therefore, when the drain superheat degree DSH is within a predetermined range, it may be ensured that the refrigerant sucked back through the air inlet of the compressor is gaseous.

[0033] During the operating process of the air conditioning system, the pressure P of the air outlet of the compressor and the temperature Tc of the air outlet are detected in real time, an acquiring module may be configured to acquire drain saturation temperature Tp according to the pressure P of the air outlet of the compressor detected in real time, and to calculate a difference between the temperature Tc of the air outlet and the drain saturation temperature Tp as real-time drain superheat degree DSH. Therefore, the real-time drain superheat degree DSH may be used for anti-liquid-slugging control.

[0034] In block S20, when the drain superheat degree DSH is less than a first preset value M1 for a first preset time period t1, a timer is controlled to start timing.

[0035] In block S30, when a counted time period t of the timer reaches a second preset time period t2, an outdoor unit of the air conditioning system is controlled to shut down for preventing the compressor from the liquid-slugging.

[0036] According to a specific embodiment of the present disclosure, the first preset time period t1 may be 20 minutes, the second preset time period t2 may be 30 minutes, and the first preset value M1 may be A°C.

[0037] Specifically, the drain superheat degree DSH

of the compressor is acquired in real time, and the drain superheat degree DSH is monitored during the operating process of the air conditioning system to determine whether the drain superheat degree DSH of the air conditioning system is greater than or equal to the first preset value M1. When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C), it is indicated that a suction superheat degree SSH of the air conditioning system is sufficiently large, such that the outdoor unit of the air conditioning system is controlled to operate normally. The refrigerant sucked back through the air inlet of the compressor is gaseous. When the drain superheat degree DSH is less than the first preset value M1, it is further determined whether a duration reaches the first preset time period t1 (such as 20 minutes). When the duration reaches the first preset time period t1, the timer is controlled to start timing.

[0038] Further, it is determined whether the counted time period t of the timer reaches a second preset time period t2 (such as 30 minutes). When the counted time period t of the timer reaches the second preset time period t2, that is the duration when the drain superheat degree DSH is less than the first preset value M1 reaches a second preset time period t2, it is indicated that the suction superheat degree SSH of the air conditioning system is relatively low. The outdoor unit of the air conditioning system is controlled to shut down for preventing liquid refrigerant from being sucked back through the air inlet of the compressor and avoiding the compressor being suffered from the liquid-slugging.

[0039] According to an embodiment of the present disclosure, during a timing process of the timer, when the drain superheat degree DSH is greater than or equal to the first preset value M1 for a third preset time period t3, the timer is reset and the control method continues to determine whether the drain superheat degree satisfies a condition that the timer starts timing.

[0040] According to a specific embodiment of the present disclosure, the third preset time period t3 may be 5 minutes.

[0041] Specifically, during the timing process of the timer, the drain superheat degree DSH is monitored in real time. When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C), it is further determined whether a duration reaches the third preset time period t3 (such as 5 minutes). When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C) for the third preset time period t3, the timer is reset and it is determined again whether the drain superheat degree DSH satisfies the condition that the timer starts timing.

[0042] According to an embodiment of the present disclosure, after the outdoor unit is controlled to shut down, it is further determined whether a number N of anti-liquid-slugging protection activated by the air conditioning system during a fourth preset time period t4 exceeds a preset number (such as one). While the number N of the anti-liquid-slugging protection activated by the air condition-

ing system during the fourth preset time period t4 exceeds the preset number (such as one), the outdoor unit is controlled to be unrecoverable without being powered off. While the number N of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period t4 does not exceed the preset number (such as one), the timer is reset, and the outdoor unit is controlled to restart after a fifth preset time period.

[0043] According to a specific embodiment of the present disclosure, the fourth preset time period t4 may be 120 minutes and the fifth preset time period may be 6 minutes.

[0044] Specifically, the number N of the anti-liquid-slugging protection activated by the air conditioning system (that is, the number of controlling the outdoor unit to shut down) may be counted by a counter. While the number N of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period t4 (such as 120 minutes) exceeds the preset number (such as one), it is indicated that the suction superheat degree SSH of the air conditioning system keeps continuously relatively low, such that the outdoor unit is controlled to be unrecoverable without being powered off. That is, after the outdoor unit is powered off, the outdoor unit can be recoverably started. While the number N of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period t4 (such as 120 minutes) does not exceed the preset number (such as one), the timer is reset and the outdoor unit is automatically controlled to restart after the fifth preset time period t5 (such as 6 minutes), and it is determined again whether the drain superheat degree DSH satisfies the condition that the timer starts timing.

[0045] As described above and illustrated in Fig. 4, the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may specifically include the following.

[0046] In block S101, the anti-liquid-slugging protection control is activated.

[0047] In block S102, the drain superheat degree DSH of the compressor is acquired in real time and the drain superheat degree DSH is monitored during the operating process of the air conditioning system.

[0048] In block S103, it is determined whether the drain superheat degree DSH is less than the first preset value M1.

[0049] If yes, a block S104 is executed. If no, a block S105 is executed.

[0050] In block S104, it is determined whether a duration reaches the first preset time period t1.

[0051] If yes, a block S106 is executed. If no, the block S103 is executed.

[0052] In block S105, the outdoor unit of the air conditioning system is controlled to operate normally.

[0053] In block S106, the timer is controlled to start timing.

[0054] In block S107, it is determined whether the drain

superheat degree DSH is greater than or equal to the first preset value M1.

[0055] If yes, a block S108 is executed. If no, a block S110 is executed.

[0056] In block S108, it is determined whether a duration reaches the third preset time period t3.

[0057] If yes, a block S109 is executed. If no, the block S107 is executed.

[0058] In block S109, the timer is reset and the block S102 is executed.

[0059] In block S110, it is determined whether the counted time period t of the timer reaches the second preset time period t2.

[0060] If yes, a block S11 is executed. If no, the block S107 is executed.

[0061] In block S11, the outdoor unit of the air conditioning system is controlled to shut down.

[0062] In block S112, it is determined whether the number N of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period t4 exceeds the preset number (such as one).

[0063] If yes, a block S113 is executed. If no, a block S114 is executed.

[0064] In block S113, the outdoor unit is controlled to be unrecoverable without being powered off.

[0065] In block S114, the timer is reset, and the outdoor unit is controlled to restart after the fifth preset time period t5, and the block S102 is executed.

[0066] In block S115, the anti-liquid-slugging control ends.

[0067] In conclusion, with the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure, by acquiring the drain superheat degree of the compressor in real time, and by monitoring the drain superheat degree during the operating process of the air conditioning system, the timer is controlled to start timing when the drain superheat degree is less than the first preset value for the first preset time period; and the outdoor unit of the air conditioning system is controlled to shut down for preventing the compressor from the liquid-slugging when the counted time period of the timer reaches the second preset time period. Therefore, the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may realize anti-liquid-slugging protection by monitoring the drain superheat degree of the compressor in real time, such that it may be ensured that refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0068] Fig. 3 is a flow chart illustrating a control method

of anti-liquid-slugging of air conditioning system according to another embodiment of the present disclosure. The air conditioning system includes the compressor, a condenser and an evaporator. As illustrated in Fig. 3, the control method of anti-liquid-slugging of air conditioning system includes the followings.

[0069] In block S1, temperature T_c of an air outlet of the compressor is detected and temperature T_1 of a middle part of the condenser and temperature T_2 of a middle part of the evaporator are detected.

[0070] In block S2, when the air conditioning system is in a refrigerating mode, the drain superheat degree DSH of the compressor is calculated according to the temperature T_c of the air outlet and the temperature T_1 of the middle part of the condenser.

[0071] In block S3, when the air conditioning system is in a heating mode, the drain superheat degree DSH of the compressor is calculated according to the temperature T_c of the air outlet and the temperature T_2 of the middle part of the evaporator.

[0072] Specifically, based on analysis of the operating process of the air conditioning system, a pressure vs enthalpy diagram illustrated in Fig. 2 may be obtained. In the diagram, a longitudinal coordinate represent a logarithm value LogP of an absolute pressure of the air conditioning system, while a horizontal coordinate represents a specific enthalpy value b of the air conditioning system. As illustrated in Fig. 2, the air conditioning system is in a superheat and exothermic phase indicated by segments 1-2, where gaseous refrigerant with high temperature and high pressure is exhausted from the air outlet of the compressor. The air conditioning system is in a constant pressure and exothermic phase indicated by segments 2-4. The air conditioning system is in a constant pressure and endothermic phase indicated by segments 5-6. The air conditioning system is in a superheat and endothermic phase indicated by segments 6-7, where the refrigerant is sucked back through an air inlet of the compressor. As illustrated in Fig. 2, the drain superheat degree DSH of the air conditioning system corresponds to the suction superheat degree SSH, and the value of the drain superheat degree DSH is greater than the value of the suction superheat degree SSH. Therefore, when the drain superheat degree DSH is within a predetermined range, it may be ensured that the refrigerant sucked back through the air inlet of the compressor is gaseous.

[0073] During the operating process of the air conditioning system, the temperature T_c of the air outlet of the compressor is detected in real time, and the temperature T_1 of the middle part of the condenser and the temperature T_2 of the middle part of the evaporator are detected. When the air conditioning system is in the refrigerating mode, the temperature T_1 of the middle part of the condenser is equivalent to saturation temperature at a high pressure side of the air conditioning system. That is, the temperature T_1 of the middle part of the condenser may be determined as drain saturation temperature. There-

fore, the drain superheat degree DSH of the compressor may be nearly represented as a difference ($T_c - T_1$) between the temperature T_c of the air outlet of the compressor and the temperature T_1 of the middle part of the condenser. When the air conditioning system is in the heating mode, the temperature T_2 of the middle part of the evaporator is equivalent to the saturation temperature at the high pressure side of the air conditioning system. That is, the temperature T_2 of the middle part of the evaporator may be determined as the drain saturation temperature. Therefore, the drain superheat degree DSH of the compressor may be nearly represented as a difference ($T_c - T_2$) between the temperature T_c of the air outlet of the compressor and the temperature T_2 of the middle part of the evaporator. Further, the real-time drain superheat degree DSH may be used for anti-liquid-slugging control.

[0074] In block S4, the drain superheat degree DSH is monitored during the operating process of the air conditioning system.

[0075] In block S5, when the drain superheat degree DSH is less than a first preset value M_1 for a first preset time period t_1 , the timer is controlled to start timing. When a counted time period t of the timer reaches a second preset time period t_2 , an outdoor unit of the air conditioning system is controlled to shut down for preventing the compressor from liquid-slugging.

[0076] According to a specific embodiment of the present disclosure, the first preset time period t_1 may be 20 minutes, the second preset time period t_2 may be 30 minutes and the first preset value M_1 may be $^{\circ}\text{C}$.

[0077] Specifically, the drain superheat degree DSH of the compressor is acquired in real time, and the drain superheat degree DSH is monitored during the operating process of the air conditioning system to determine whether the drain superheat degree DSH of the air conditioning system is greater than or equal to the first preset value M_1 . When the drain superheat degree DSH is greater than or equal to the first preset value M_1 (such as $^{\circ}\text{C}$), it is indicated that the suction superheat degree SSH of the air conditioning system is sufficiently large. The outdoor unit of the air conditioning system keeps operating normally and the refrigerant sucked back through the air inlet of the compressor is gaseous. When the drain superheat degree DSH is less than the first preset value M_1 , it is further determined whether a duration reaches the first preset time period t_1 (such as 20 minutes). When the duration reaches the first preset time period t_1 , the timer is controlled to start timing.

[0078] Further, it is determined whether the counted time period t of the timer reaches the second preset time period t_2 (such as 30 minutes). When the counted time period t of the timer reaches the second preset time period t_2 , that is the duration when the drain superheat degree DSH is less than the first preset value M_1 reaches the second preset time period t_2 , it is indicated that the suction superheat degree SSH of the air conditioning system is relatively low. Therefore, the outdoor unit of the

air conditioning system is controlled to shut down for preventing liquid refrigerant from being sucked back through the air inlet of the compressor and avoiding the compressor being suffered from the liquid-slugging.

[0079] According to an embodiment of the present disclosure, during the timing process of the timer, when the drain superheat degree DSH is greater than or equal to the first preset value M1 for a third preset time period t3, the timer is reset, and the control method continues to determine whether the drain superheat degree DSH satisfies a condition that the timer starts timing.

[0080] According to a specific embodiment of the present disclosure, the third preset time period t3 may be 5 minutes.

[0081] Specifically, during the timing process of the timer, the drain superheat degree DSH is monitored in real time. When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C), it is further determined whether the duration reaches the third preset time period t3 (such as 5 minutes). When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C) for the third preset time period t3, the timer is reset and it is determined again whether the drain superheat degree DSH satisfies the condition that the timer starts timing.

[0082] According to an embodiment of the present disclosure, after the outdoor unit is controlled to shut down, it is further determined whether a number N of anti-liquid-slugging activated by the air conditioning system during a fourth preset time period t4 exceeds a preset number (such as one). While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 exceeds the preset number (such as one), the outdoor unit is controlled to be unrecoverable without being powered off. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 does not exceed the preset number (such as one), the timer is reset and the outdoor unit is controlled to restart after a fifth preset time period t5.

[0083] According to a specific embodiment of the present disclosure, the fourth preset time period t4 may be 120 minutes, and the fifth preset time period t5 may be 6 minutes.

[0084] Specifically, the number N of the anti-liquid-slugging activated by the air conditioning system (i.e., the number of controlling the outdoor unit to shut down) may be counted via a counter. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 (such as 120 minutes) exceeds the preset number (such as one), it is indicated that the suction superheat degree SSH of the air conditioning system keeps continuously relatively low, such that the outdoor unit is unrecoverable without being powered off. That is, after the outdoor unit is powered off, the outdoor unit can be recoverably started. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset

time period t4 (such as 120 minutes) does not exceed the preset number (such as one), the timer is reset and the outdoor unit is automatically controlled to restart after the fifth preset time period t5 (such as 6 minutes). In addition, it is determined again whether the drain superheat degree DSH satisfies the condition that the timer starts timing.

[0085] As described above and illustrated in Fig. 4, the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may specifically include the following.

[0086] In block S101, the anti-liquid-slugging protection control is activated.

[0087] In block S102, the drain superheat degree DSH of the compressor is acquired in real time and the drain superheat degree DSH is monitored during the operating process of the air conditioning system.

[0088] In block S103, it is determined whether the drain superheat degree DSH is less than the first preset value M1.

[0089] If yes, a block S104 is executed. If no, a block S105 is executed.

[0090] In block S104, it is determined whether a duration reaches the first preset time period t1.

[0091] If yes, a block S106 is executed. If no, the block S103 is executed.

[0092] In block S105, the outdoor unit of the air conditioning system is controlled to operate normally.

[0093] In block S106, the timer is controlled to start timing.

[0094] In block S107, it is determined whether the drain superheat degree DSH is greater than or equal to the first preset value M1.

[0095] If yes, a block S108 is executed. If no, a block S110 is executed.

[0096] In block S108, it is determined whether a duration reaches the third preset time period t3.

[0097] If yes, a block S109 is executed. If no, the block S107 is executed.

[0098] In block S109, the timer is reset and the block S102 is executed.

[0099] In block S110, it is determined whether the counted time period t of the timer reaches the second preset time period t2.

[0100] If yes, a block S111 is executed. If no, the block S107 is executed.

[0101] In block S111, the outdoor unit of the air conditioning system is controlled to shut down.

[0102] In block S112, it is determined whether the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 exceeds the preset number (such as one).

[0103] If yes, a block S113 is executed. If no, a block S114 is executed.

[0104] In block S113, the outdoor unit is controlled to be unrecoverable without being powered off.

[0105] In block S114, the timer is reset, and the outdoor unit is controlled to restart after the fifth preset time period

t5, and the block S102 is executed.

[0106] In block S115, the anti-liquid-slugging control ends.

[0107] In conclusion, with the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure, by detecting the temperature of the air outlet of the compressor, and by detecting the temperature of the middle part of the condenser and the temperature of the middle part of the evaporator, when the air conditioning system is in the refrigerating mode, the drain superheat degree of the compressor is calculated according to the temperature of the air outlet and the temperature of the middle part of the condenser, and when the air conditioning system is in the heating mode, the drain superheat degree of the compressor is calculated according to the temperature of the air outlet and the temperature of the middle part of the evaporator, by monitoring the drain superheat degree during the operating process of the air conditioning system, the timer is controlled to start timing when the drain superheat degree is less than the first preset value for the first preset time period; and the outdoor unit of the air conditioning system is controlled to shut down for preventing the compressor from the liquid-slugging when the counted time period of the timer reaches the second preset time period. Therefore, the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may realize anti-liquid-slugging protection by monitoring the drain superheat degree of the compressor in real time, such that it may be ensured that the refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0108] Embodiments of the present disclosure further provide a non-transitory computer readable storage medium, having computer programs stored thereon. When the computer programs are executed by a processor, the control method of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure is realized.

[0109] Fig. 5 is a block diagram illustrating a control device of anti-liquid-slugging of air conditioning system according to an embodiment of the present disclosure. As illustrated in Fig. 5, the control device includes an acquiring module 10, a monitoring module 20 and a control module 30. The acquiring module 10 is configured to acquire a drain superheat degree DSH of a compressor in real time. The monitoring module 20 is configured to monitor the drain superheat degree during an operating process of the air conditioning system. The control module 30 is configured to control a timer 60 to start timing

when the drain superheat degree is less than a first preset value M1 for a first preset time period t1, and to control an outdoor unit of the air conditioning system to shut down for preventing the compressor from the liquid-slugging when a counted time period of the timer 60 reaches a second preset time period t2.

[0110] According to a specific embodiment of the present disclosure, the first preset time period t1 may be 20 minutes, the second preset time period t2 may be 30 minutes and the first preset value M1 may be A°C.

[0111] Specifically, the acquiring module 10 is configured to acquire the drain superheat degree DSH of the compressor in real time, the monitoring module 20 is configured to monitor the drain superheat degree DSH during the operating process of the air conditioning system, and to determine whether the drain superheat degree DSH of the air conditioning system is greater than or equal to the first preset value M1. When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C), it is indicated that a suction superheat degree SSH of the air conditioning system is sufficiently large, such that the control module 30 controls the outdoor unit of the air conditioning system to keep operating normally. Refrigerant sucked back through an air inlet of the compressor is gaseous. When the drain superheat degree DSH is less than the first preset value M1, the control module 30 is configured to further determine whether a duration reaches the first preset time period t1 (such as 20 minutes). When the duration reaches the first preset time period t1, the control module 30 is configured to control the timer 60 to start timing.

[0112] Further, the control module 30 is configured to determine whether a counted time period t of the timer 60 reaches the second preset time period t2 (such as 30 minutes). When the counted time period t of the timer 60 reaches the second preset time period t2, that is the duration when the drain superheat degree DSH is less than the first preset value M1 reaches the second preset time period t2, the suction superheat degree SSH of the air conditioning system is accordingly relatively low, the control module 30 is configured to control the outdoor unit of the air conditioning system to shut down for preventing liquid refrigerant from being sucked back through the air inlet of the compressor, and avoiding the compressor being suffered from the liquid-slugging.

[0113] According to an embodiment of the present disclosure, as illustrated in Fig. 6, the control device of anti-liquid-slugging of air conditioning system further includes a fourth temperature sensor 40 and a pressure sensor 50 arranged at the air outlet of the compressor. The fourth temperature sensor 40 is configured to detect temperature Tc of the air outlet of the compressor, and the pressure sensor 50 is configured to detect pressure P of the air outlet of the compressor. The acquiring module 10 is configured to calculate the drain superheat degree DSH of the compressor according to the pressure P of the air outlet and the temperature Tc of the air outlet.

[0114] According to a specific embodiment of the

present disclosure, the fourth temperature sensor 40 may be a drain temperature sensing bulb.

[0115] Based on analysis of the operating process of the air conditioning system, a pressure vs enthalpy diagram illustrated in Fig. 2 may be obtained. In the diagram, a longitudinal coordinate represents a logarithm value LogP of an absolute pressure of the air conditioning system, while a horizontal coordinate represents a specific enthalpy value b of the air conditioning system. As illustrated in Fig. 2, the air conditioning system is in a superheat and exothermic phase indicated by segments 1-2, where gaseous refrigerant with high temperature and high pressure is exhausted from the air outlet of the compressor. The air conditioning system is in a constant pressure and exothermic phase indicated by segments 2-4. The air conditioning system is in a constant pressure and endothermic phase indicated by segments 5-6. The air conditioning system is in a superheat and endothermic phase indicated by segments 6-7, where the refrigerant is sucked back through the air inlet of the compressor. As illustrated in Fig. 2, the drain superheat degree DSH of the air conditioning system corresponds to the suction superheat degree SSH, and the value of the drain superheat degree DSH is greater than the value of the suction superheat degree SSH. Therefore, when the drain superheat degree DSH is within a predetermined range, it may be ensured that the refrigerant sucked back through the air inlet of the compressor is gaseous.

[0116] During the operating process of the air conditioning system, the pressure P of the air outlet of the compressor and the temperature Tc of the air outlet are detected in real time, the acquiring module may be configured to acquire drain saturation temperature Tp according to the pressure P of the air outlet of the compressor detected in real time, and to calculate a difference between the temperature Tc of the air outlet and the drain saturation temperature Tp as real-time drain superheat degree DSH. Therefore, the real-time drain superheat degree DSH may be used for anti-liquid-slugging control.

[0117] According to an embodiment of present disclosure, during a timing process of the timer 60, when the drain superheat degree DSH is greater than or equal to the first preset value M1 for a third preset time period t3, the control module 30 is configured to reset the timer 60 and continue to determine whether the drain superheat degree DSH satisfies a condition that the timer 60 starts timing.

[0118] According to a specific embodiment of the present disclosure, the third preset time period t3 may be 5 minutes.

[0119] Specifically, during the timing process of the timer 60, the monitoring module 20 is configured to monitor the drain superheat degree DSH in real time. When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C), the control module 30 is configured to further determine whether a duration reaches the third preset time period t3 (such as 5 minutes). When the drain superheat degree DSH is

greater than or equal to the first preset value M1 (such as A°C) for the third preset time period t3, the control module 30 is configured to reset the timer 60 and determine again whether the drain superheat degree DSH satisfies the condition that the timer 60 starts timing.

[0120] According to an embodiment of the present disclosure, after the outdoor unit is controlled to shut down, the control module 30 is configured to further determine whether a number N of anti-liquid-slugging activated by the air conditioning system during a fourth preset time period t4 exceeds a preset number (such as one). While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 exceeds the preset number (such as one), the control module 30 is configured to control the outdoor unit to be unrecoverable without being powered off. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 does not exceed the preset number (such as one), the control module 30 is configured to reset the timer 60 and control the outdoor unit to restart after a fifth preset time period t5.

[0121] According to a specific embodiment of the present disclosure, the fourth preset time period t4 may be 120 minutes and the fifth preset time period t5 may be 6 minutes.

[0122] Specifically, the number N of the anti-liquid-slugging activated by the air conditioning system (i.e., the number of controlling the outdoor unit to shut down) may be counted via a counter. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 exceeds the preset number (such as one), it is indicated that the suction superheat degree SSH of the air conditioning system keeps continuously relatively low. The control module 30 is configured to control the outdoor unit to be unrecoverable without being powered off. That is, after the outdoor unit is powered off, the outdoor unit can be recoverably started. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 (such as 120 minutes) does not exceed the preset number (such as one), the control module 30 is configured to reset the timer and automatically control the outdoor unit to restart after the fifth preset time period t5 (such as 6 minutes), and determine again whether the drain superheat degree DSH satisfies the condition that the timer 60 starts timing.

[0123] In conclusion, according to the control device of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure, by acquiring the drain superheat degree of the compressor in real time with the acquiring module, and by monitoring the drain superheat degree with the monitoring module during the operating process of the air conditioning system, the control module is configured to control the timer to start timing when the drain superheat degree is less than the first preset value for the first preset time period; and the control module is configured to control the outdoor

unit of the air conditioning system to shut down for preventing the compressor from the liquid-slugging when the counted time period of the timer reaches the second preset time period. Therefore, the control device of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may realize anti-liquid-slugging protection by monitoring the drain superheat degree of the compressor in real time, such that it may be ensured that refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0124] Fig. 7 is a block diagram illustrating a control device of anti-liquid-slugging of air conditioning system according to another embodiment of the present disclosure. As illustrated in Fig. 7, the control device includes a first temperature sensor 70, a second temperature sensor 80, a third temperature sensor 90 and the acquiring module 10 (i.e., the calculating module 11 in embodiments illustrated in Fig. 7), the monitoring module 20 and the control module 30.

[0125] As illustrated in Fig. 8, the first temperature sensor 70 is arranged at the air outlet of the compressor 100. The first temperature sensor 70 is configured to detect temperature T_c of the air outlet of the compressor 10. The second temperature sensor 80 is arranged at a middle part of the evaporator 200, and the second temperature sensor 80 is configured to detect temperature T_1 of the middle part of the evaporator 200. The third temperature sensor 90 is arranged at a middle part of the condenser 300, and the third temperature sensor 90 is configured to detect temperature T_2 of the middle part of the condenser 300. The acquiring module 10 (i.e., the calculating module 11) is configured to, when the air conditioning system is in a refrigerating mode, calculate the drain superheat degree DSH of the compressor 100 according to the temperature T_c of the air outlet and the temperature T_2 of the middle part of the condenser 300, and when the air conditioning system is in a heating mode, calculate the drain superheat degree DSH of the compressor 100 according to the temperature T_c of the air outlet and the temperature T_1 of the middle part of the evaporator 200. The monitoring module 20 is configured to monitor the drain superheat degree DSH during the operating process of the air conditioning system. The control module 30 is configured to control the timer 60 to start timing when the drain superheat degree DSH is less than the first preset value M_1 for the first preset time period t_1 , and control the outdoor unit of the air conditioning system to shut down for preventing the compressor from the liquid-slugging when the counted time period t of the timer 60 reaches the second preset time period t_2 .

[0126] According to a specific embodiment of the present disclosure, the first preset time period t_1 may be 20 minutes, the second preset time period t_2 may be 30 minutes and the first preset value M_1 may be $A^{\circ}C$.

[0127] Specifically, during the operating process of the air conditioning system, the first temperature sensor 70 is configured to detect the temperature T_c of the air outlet of compressor 100 in real time, the second temperature sensor 80 is configured to detect the temperature T_1 of the middle part of the condenser 300 in real time, and the third temperature sensor 90 is configured to detect the temperature T_2 of the evaporator 200 in real time. When the air conditioning system is in the refrigerating mode, the temperature T_1 of the middle part of the condenser 300 is equivalent to saturation temperature at a high pressure side of the air conditioning system. That is, the temperature T_1 of the middle part of the condenser 300 may be determined as drain saturation temperature. Therefore, the drain superheat degree DSH of the compressor 100 may be nearly represented as a difference ($T_c - T_1$) between the temperature T_c of the air outlet of the compressor 100 and the temperature T_1 of the middle part of the condenser 300. When the air conditioning system is in the heating mode, the temperature T_2 of the middle part of the evaporator 200 is equivalent to the saturation temperature at the high pressure side of the air conditioning system. That is, the temperature T_2 of the middle part of the evaporator 200 may be determined as the drain saturation temperature. The drain superheat degree DSH of the compressor 100 may be nearly represented as a difference ($T_c - T_2$) between the temperature T_c of the air outlet of the compressor 100 and the temperature T_2 of the middle part of the evaporator 200. The real-time drain superheat degree DSH may be used for anti-liquid-slugging control.

[0128] As such, when the air conditioning system is in the refrigerating mode, the calculating module 11 is configured to calculate the drain superheat degree DSH of the compressor 100 according to the temperature T_c of the air outlet of the compressor 100 and the temperature T_1 of the middle part of the condenser 300. When the air conditioning system is in the heating mode, the calculating module 11 is configured to calculate the drain superheat degree DSH of the compressor 100 according to the temperature T_c of the air outlet of the compressor 100 and the temperature T_2 of the middle part of the evaporator 200. The monitoring module 20 is configured to monitor the drain superheat degree DSH during the operating process of the air conditioning system, and determine whether the drain superheat degree DSH of the air conditioning system is greater than or equal to the first preset value M_1 . When the drain superheat degree DSH is greater than or equal to the first preset value M_1 (such as $A^{\circ}C$), it is indicated that the suction superheat degree DSH of the air conditioning system is relatively large. The control module 30 is configured to control the outdoor unit of the air conditioning system to keep operating normally. The refrigerant sucked back through the

air inlet of the compressor 100 is gaseous. When the drain superheat degree DSH is less than the first preset value M1, the control module 30 is configured to further determine whether a duration reaches the first preset time period t1 (such as 20 minutes). When the duration reaches the first preset time period t1, the control module 30 is configured to control the timer 60 to start timing.

[0129] Further, the control module 30 is configured to determine whether the counted time period t of the timer 60 reaches the second preset time period t2 (such as 30 minutes). When the counted time period t of the timer 60 reaches the second preset time period t2, that is, the duration when the drain superheat degree DSH is less than the first preset value M1 reaches the second preset time period t2, the suction superheat degree SSH of the air conditioning system is accordingly relatively low, the control module 30 is configured to control the outdoor unit of the air conditioning system to shut down for preventing liquid refrigerant from being sucked back through the air inlet of the compressor 100 and avoiding the compressor 100 being suffered from the liquid-slugging.

[0130] According to an embodiment of the present disclosure, during the timing process of the timer 60, when the drain superheat degree DSH is greater than the first preset value M1 for the third preset time period t3, the control module 30 is configured to reset the timer 60 and continue to determine whether the drain superheat degree DSH satisfies the condition that the timer 60 starts timing.

[0131] According to a specific embodiment of the present disclosure, the third preset time period t3 may be 5 minutes.

[0132] Specifically, during the timing process of the timer 60, the monitoring module 20 is configured to monitor the drain superheat degree DSH in real time. When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C), the control module 30 may be configured to further determine whether a duration reaches the third preset time period t3 (such as 5 minutes). When the drain superheat degree DSH is greater than or equal to the first preset value M1 (such as A°C) for the third preset time period t3, the control module 30 is configured to reset the timer 60 and to determine again whether the drain superheat degree DSH satisfies the condition that the timer 60 starts timing.

[0133] According to an embodiment of the present disclosure, after the outdoor unit is controlled to shut down, the control module 30 is further configured to determine whether a number N of anti-liquid-slugging activated by the air conditioning system during a fourth preset time period t4 exceeds a preset number (such as two). While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 exceeds the preset number (such as two), the control module 30 is configured to control the outdoor unit to be unrecoverable without being powered off. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time pe-

riod t4 does not exceed the preset number (such as two), the control module 30 is configured to reset the timer 60 and control the outdoor unit to restart after a fifth preset time period t5.

[0134] According to a specific embodiment of the present disclosure, the fourth preset time period t4 may be 120 minutes, and the fifth preset time period t5 may be 6 minutes.

[0135] Specifically, the number N of the anti-liquid-slugging activated by the air conditioning system (that is the number of controlling the outdoor unit to shut down) may be counted by a counter. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 (such as 120 minutes) exceeds the preset number (such as one), it is indicated that the suction superheat degree SSH of the air conditioning system keeps continuously relatively low. The control module 30 is configured to control the outdoor unit to be unrecoverable without being powered off. That is, it is required to power the outdoor unit off, and the outdoor unit can be recoverably started. While the number N of the anti-liquid-slugging activated by the air conditioning system during the fourth preset time period t4 (such as 120 minutes) does not exceed the preset number (such as one), the control module 30 is configured to reset the timer 60 and automatically control the outdoor unit to restart after the fifth preset time period t5 (such as 6 minutes), and determine again whether the drain superheat degree DSH satisfies the condition that the timer 60 starts timing.

[0136] In conclusion, with the control device of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure, by detecting the temperature of the air outlet of the compressor with the first temperature sensor, by detecting the temperature of the middle part of the evaporator with the second temperature sensor and by detecting the temperature of the middle part of the condenser with the third temperature sensor, the drain superheat degree of the compressor is calculated via the calculating module according to the temperature of the air outlet and the temperature of the middle part of the condenser when the air conditioning system is in the refrigerating mode and the drain superheat degree of the compressor is calculated via the calculating module according to the temperature of the air outlet and the temperature of the middle part of the evaporator when the air conditioning system is in the heating mode. The monitoring module 20 is configured to monitor the drain superheat degree during the operating process of the air conditioning system. The control module is configured to control the timer to start timing when the drain superheat degree is less than the first preset value for the first preset time period, and to control the outdoor unit of the air conditioning system to shut down when the counted time period of the timer reaches the second preset time period. As can be seen above, the control device of anti-liquid-slugging of air conditioning system according to embodiments of the present disclosure may realize

anti-liquid-slugging protection by monitoring the drain superheat degree of the compressor in real time, such that it may be ensured that the refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0137] Fig. 9 is a block diagram illustrating an air conditioning system according to embodiments of the present disclosure. As illustrated in Fig. 9, the air conditioning system 400 includes the anti-liquid-slugging device 500 of the air conditioning system.

[0138] In conclusion, with the air conditioning system provided in embodiments of the present disclosure, an anti-liquid-slugging protection is realized by monitoring the drain superheat degree of the compressor in real time with the above control device of anti-liquid-slugging of air conditioning system, such that it may be ensured that the refrigerant sucked back through an air inlet of the compressor is gaseous, thereby preventing liquid refrigerant from entering into the compressor and avoiding the compressor being suffered from the liquid-slugging. In addition, since the value of the drain superheat degree is relatively large, which is easy for data detection and anti-liquid-slugging control, an accuracy of anti-liquid-slugging control is improved and security and reliability during the operating process of the air conditioning system are improved.

[0139] It is to be noted that, in the specification, relational terms such as "first" and "second" are used herein for distinguishing one entity or operation from another entity or operation, but not necessarily require or imply any such actual relationship or order existing among these entities or operations. Moreover, the terms "comprises", "includes" or any other variation thereof are intended to cover a non-exclusive inclusion, such that a process, method, article, or device including a series of elements includes not only those elements, but also other elements that are not explicitly listed, or includes inherent elements of such the process, method, article, or device. Without more limitation, there is no exclusion that the process, the method, the article, or the device including an element defined by the sentence "include one..." includes other same elements.

[0140] The logic and/or steps described in other manners herein or shown in the flow chart, for example, may be considered as a particular sequence table of executable instructions for realizing the logical function, may be specifically achieved in any computer readable medium to be used by the instruction execution system, device or equipment (such as the system based on computers, the system comprising processors or other systems capable of obtaining the instruction from the instruction ex-

ecution system, device and equipment and executing the instruction), or to be used in combination with the instruction execution system, device and equipment. As to the specification, "the computer readable medium" may be any device adaptive for including, storing, communicating, propagating or transferring programs to be used by or in combination with the instruction execution system, device or equipment. More specific examples of the computer readable medium (non-exhaustive list) comprise but are not limited to: an electronic connection (an electronic device) with one or more wires, a portable computer enclosure (a magnetic device), a random access memory (RAM), a read only memory (ROM), an erasable programmable read-only memory (EPROM or a flash memory), an optical fiber device and a portable compact disk read-only memory (CDROM). In addition, the computer readable medium may even be a paper or other appropriate medium capable of printing programs thereon, this is because, for example, the paper or other appropriate medium may be optically scanned and then edited, decrypted or processed with other appropriate methods when necessary to obtain the programs in an electric manner, and then the programs may be stored in the computer memories.

[0141] It should be understood that each part of the present disclosure may be realized by the hardware, software, firmware or their combination. In the above embodiments, a plurality of steps or methods may be realized by the software or firmware stored in the memory and executed by the appropriate instruction execution system. For example, if it is realized by the hardware, likewise in another embodiment, the steps or methods may be realized by one or a combination of the following techniques known in the art: a discrete logic circuit having a logic gate circuit for realizing a logic function of a data signal, an application-specific integrated circuit having an appropriate combination logic gate circuit, a programmable gate array (PGA), a field programmable gate array (FPGA), etc.

[0142] In the present disclosure, unless specified or limited otherwise, the terms "mounted," "connected," "coupled," and "fixed" are used broadly and encompass such as fixed, detachable or integral connections; also can be mechanical or electrical connections, also can be direct and indirect connections via an intermediate medium, and further can be internal connections or the interactions between two elements, unless otherwise expressly defined which can be understood by those skilled in the art according to the detail embodiment of the present disclosure.

[0143] In the description of the present disclosure, reference throughout this specification to "an embodiment", "some embodiments", "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. The appearances of the phrases in various places

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. Without a contradiction, the different embodiments or examples and the features of the different embodiments or examples can be combined by those skilled in the art.

[0144] Although explanatory embodiments have been shown and described, it would be appreciated that the above embodiments cannot be construed to limit the present disclosure, and changes, modifications, alternatives, and variants can be made by those skilled in the art within the scope of the present disclosure.

Claims

1. A control method for preventing an air conditioning system from liquid-slugging, comprising:

acquiring an drain superheat degree of a compressor in real time, and monitoring the drain superheat degree during an operating process of the air conditioning system;
when the drain superheat degree is less than a first preset value for a first preset time period, controlling a timer to start timing; and
when a counted time period of the timer reaches a second preset time period, controlling an outdoor unit of the air conditioning system to shut down for preventing the compressor from the liquid-slugging.

2. The control method according to claim 1, wherein during a timing process of the timer, when the drain superheat degree is greater than or equal to the first preset value for a third preset time period, resetting the timer and continuing to determine whether the drain superheat degree satisfies a condition that the timer starts timing.

3. The control method according to claim 1 or 2, after controlling the outdoor unit to shut down, further comprising: determining whether a number of anti-liquid-slugging protection activated by the air conditioning system during a fourth preset time period exceeds a preset number, wherein,
while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period exceeds the preset number, controlling the outdoor unit to be unrecoverable without being powered off; and
while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period does not exceed the preset number, resetting the timer, and controlling the outdoor unit to restart after a fifth preset time

period.

4. The control method according to any one of claims 1 to 3, wherein the air conditioning system comprises the compressor, a condenser and an evaporator, and acquiring the drain superheat degree of the compressor in real time comprises:

detecting temperature of an air outlet of the compressor, and detecting temperature of a middle part of the condenser and temperature of a middle part of the evaporator;
when the air conditioning system is in a refrigerating mode, calculating the drain superheat degree of the compressor according to the temperature of the air outlet and the temperature of the middle part of the condenser; and
when the air conditioning system is in a heating mode, calculating the drain superheat degree of the compressor according to the temperature of the air outlet and the temperature of the middle part of the evaporator.

5. The control method according to any one of claims 1 to 3, wherein acquiring the drain superheat degree of the compressor in real time comprises:

detecting a pressure of an air outlet of the compressor and detecting temperature of the air outlet of the compressor; and
calculating the drain superheat degree of the compressor according to the pressure of the air outlet and the temperature of the air outlet.

6. The control method according to claim 3, wherein the first preset time period is 20 minutes, the second preset time period is 30 minutes, the third preset time period is 5 minutes, the fourth preset time period is 120 minutes, and the fifth preset time period is 6 minutes.

7. A non-transitory computer readable storage medium, having computer programs stored thereon, wherein when the computer programs are executed by a processor, a control method for preventing an air conditioning system from liquid-slugging according to any one of claims 1 to 6 is implemented.

8. A control device for preventing an air conditioning system from liquid-slugging, comprising:

an acquiring module, configured to acquire a drain superheat degree of a compressor in real time;
a monitoring module, configured to monitor the drain superheat degree during an operating process of the air conditioning system;
a control module, configured to, when the drain

superheat degree is less than a first preset value for a first preset time period, control a timer to start timing; and when a counted time period of the timer reaches a second preset time period, control an outdoor unit of the air conditioning system to shut down for preventing the compressor from the liquid-slugging.

9. The control device according to claim 8, wherein during a timing process of the timer, when the drain superheat degree is greater than or equal to the first preset value for a third preset time period, the control module is configured to reset the timer and continue to determine whether the drain superheat degree satisfies a condition that the timer starts timing.
10. The control method according to claim 8 or 9, wherein after the outdoor unit is controlled to shut down, the control module is further configured to determine whether a number of anti-liquid-slugging protection activated by the air conditioning system during a fourth preset time period exceeds a preset number, wherein, while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period exceeds the preset number, the control module is configured to control the outdoor unit to be unrecoverable without being powered off; and while the number of the anti-liquid-slugging protection activated by the air conditioning system during the fourth preset time period does not exceed the preset number, the control module is configured to reset the timer, and control the outdoor unit to restart after a fifth preset time period.
11. The control device according to any one of claims 8 to 10, wherein the air conditioning system comprises the compressor, a condenser and an evaporator, and the control device further comprises:

a first temperature sensor arranged at an air outlet of the compressor and configured to detect temperature of the air outlet of the compressor; a second temperature sensor arranged at a middle part of the condenser and configured to detect temperature of the middle part of the condenser; and a third temperature sensor arranged at a middle part of the evaporator and configured to detect temperature of the middle part of the evaporator; wherein the acquiring module is further configured to calculate the drain superheat degree of the compressor according to the temperature of the air outlet and the temperature of the middle part of the condenser when the air conditioning system is in a refrigerating mode; and to calculate the drain superheat degree of the compressor

according to the temperature of the air outlet and the temperature of the middle part of the evaporator when the air conditioning system is in a heating mode.

12. The control device according to any one of claim 8 to 10, further comprising a fourth temperature sensor and a pressure sensor arranged at an air outlet of the compressor, wherein the fourth temperature sensor is configured to detect temperature of the air outlet of the compressor and the pressure sensor is configured to detect pressure of the air outlet of the compressor, and the acquiring module is configured to calculate the drain superheat degree of the compressor according to the temperature of the air outlet and the pressure of the air outlet.
13. The control device according to claim 10, wherein the first preset time period is 20 minutes, the second preset time period is 30 minutes, the third preset time period is 5 minutes, the fourth preset time period is 120 minutes, and the fifth preset time period is 6 minutes.
14. An air conditioning system, comprising the control device for preventing an air conditioning system from liquid-slugging according to any one of claims 8 to 13.

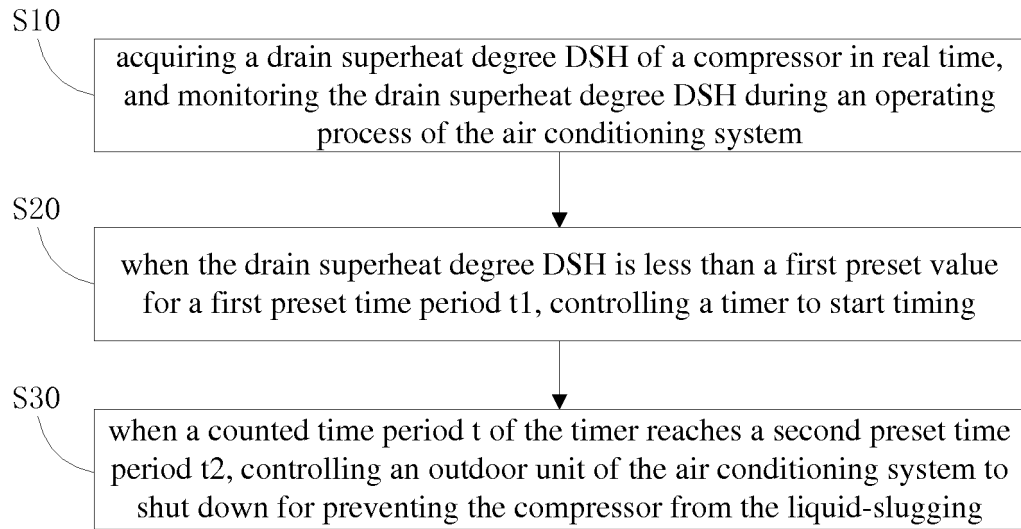


Fig. 1

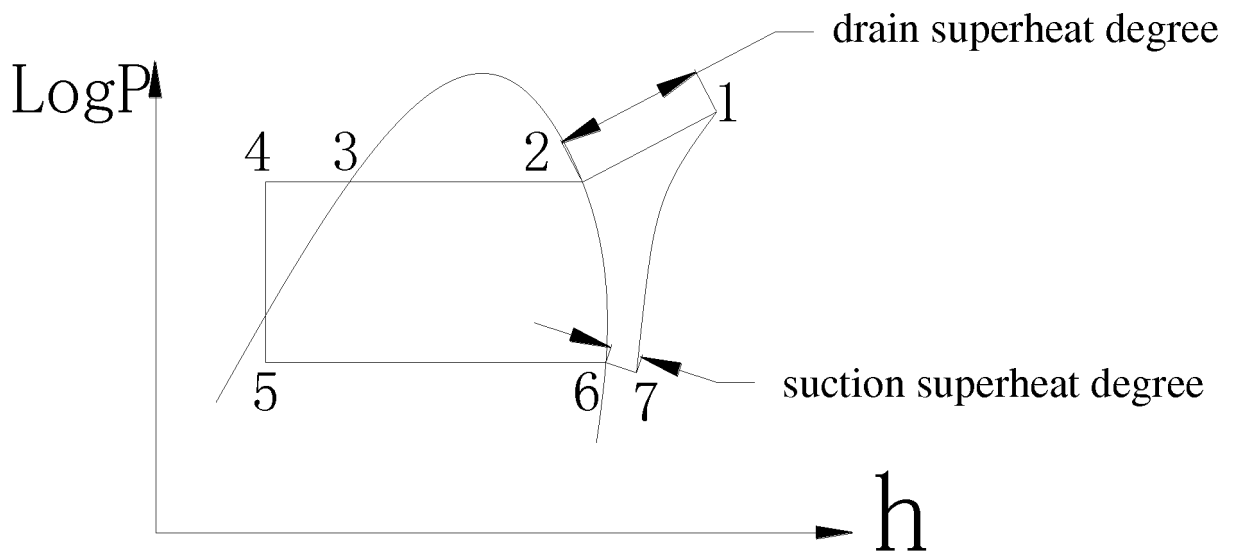


Fig. 2

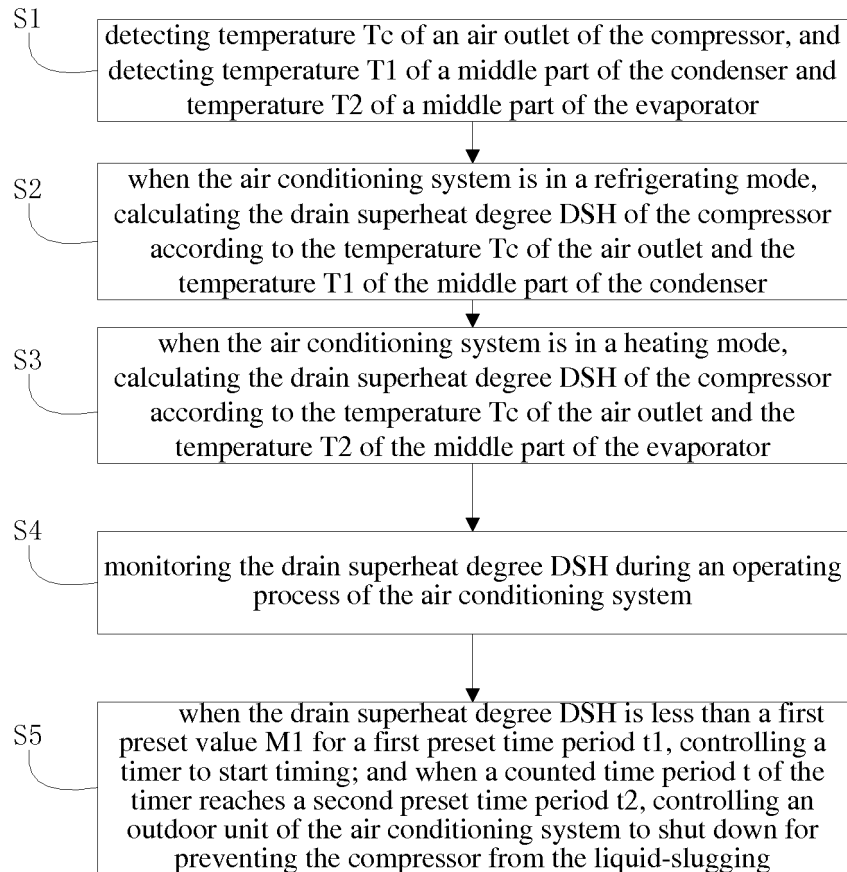


Fig. 3

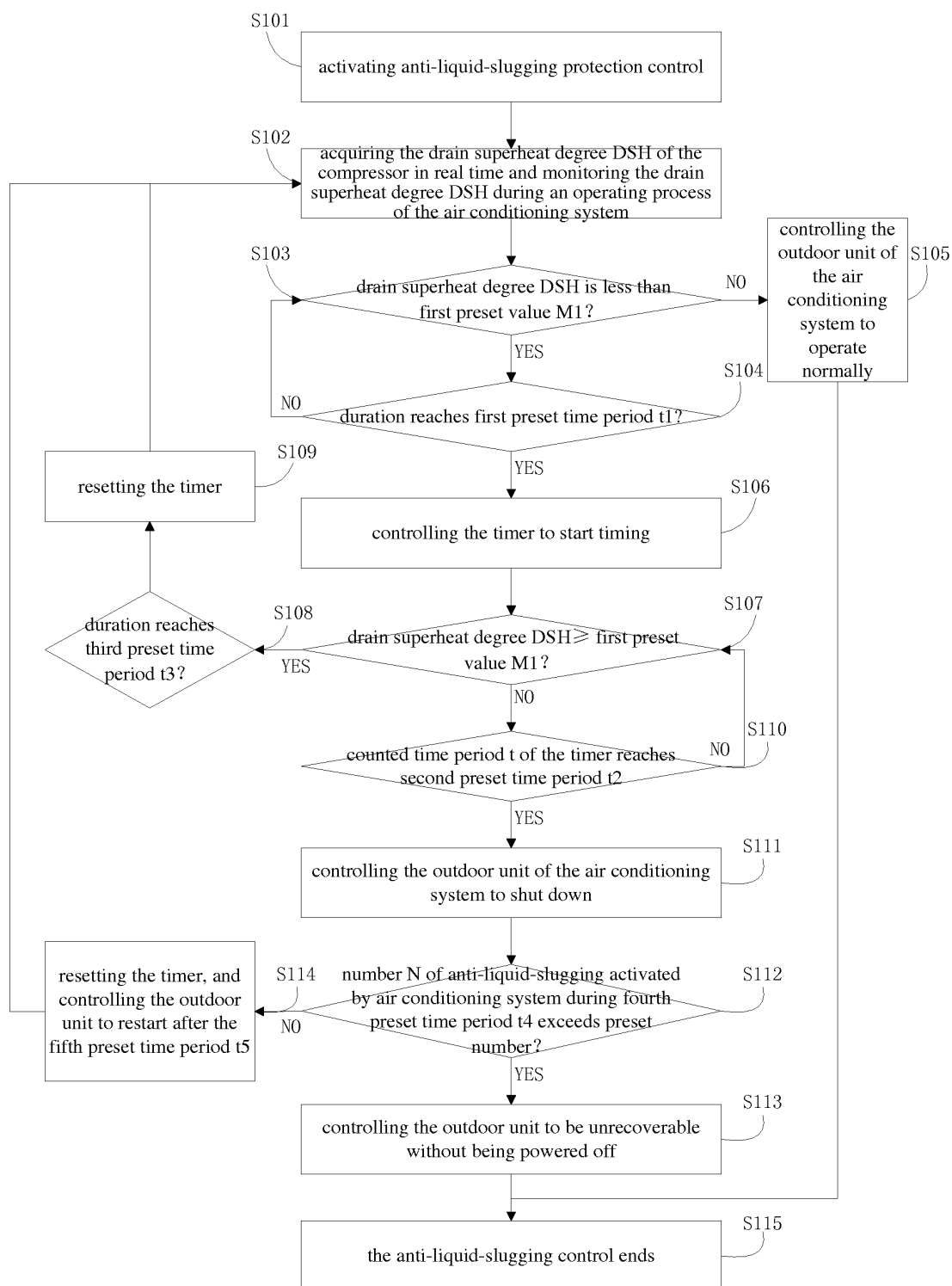


Fig. 4

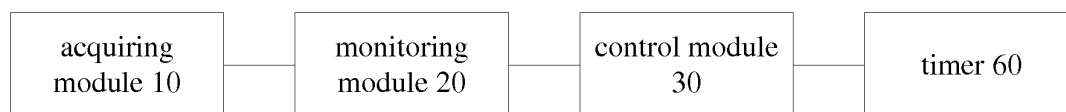


Fig. 5

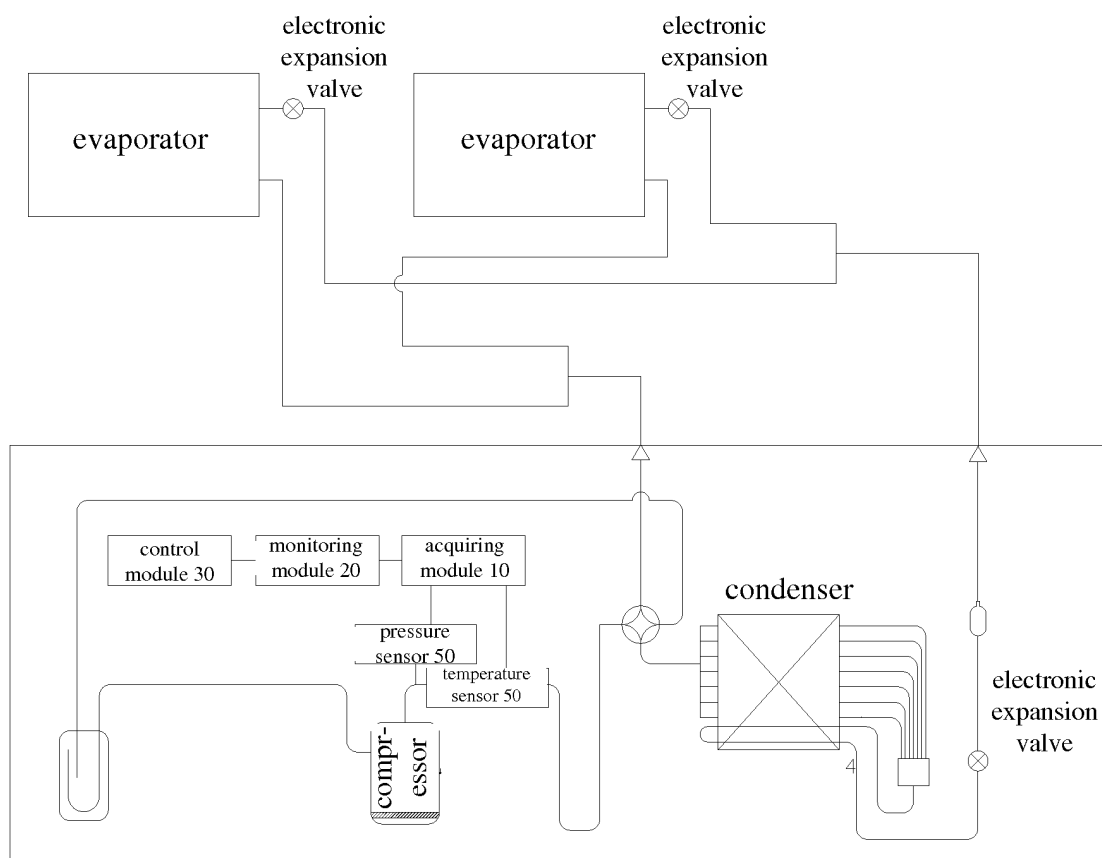


Fig. 6

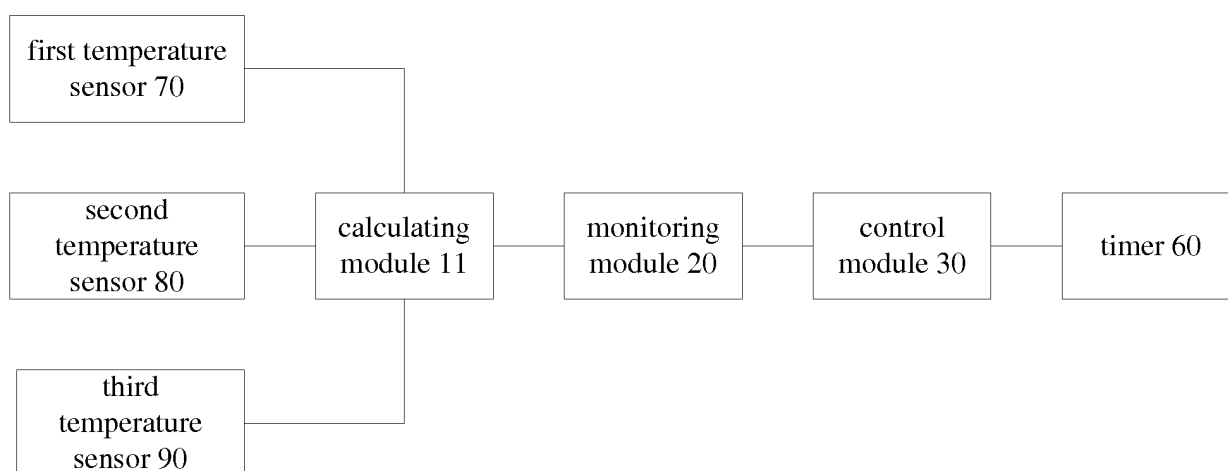


Fig. 7

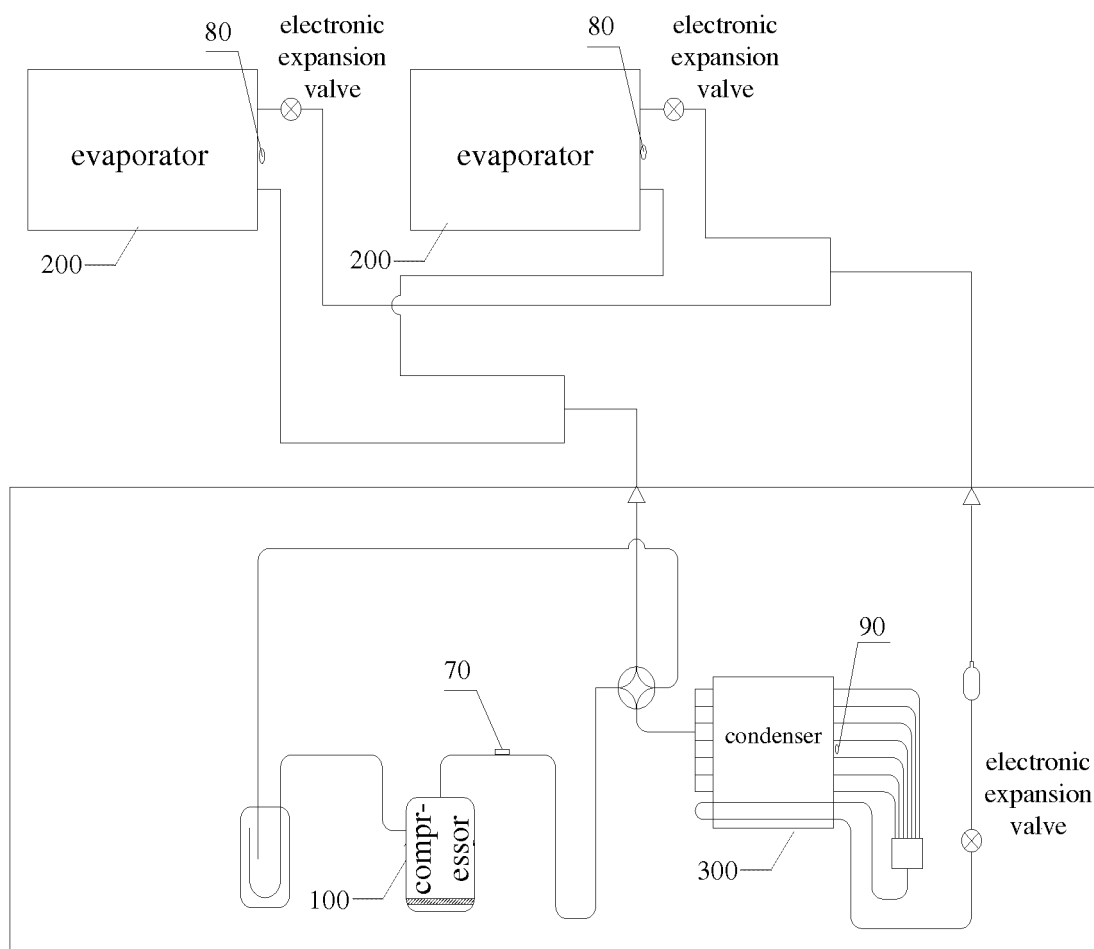


Fig. 8

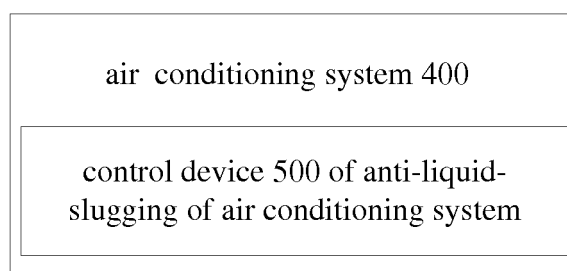


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/089642

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/02 (2006.01) i; F25B 49/02 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F; F25B; F04F 39

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

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

CPRSABS, CNTXT, CNKI, VEN, JPABS: 空调, 空气调节, 压缩机, 液击, 回液, 液体, 液态, 排气, 排放, 排出, 出口, 温度, 压力, 过热度, 过热, 时间, 时长, 计时, 停机, 关机, 关闭, 停止, 冷凝器, 蒸发器, 中间温度, 中部温度, air condition, compressor, liquid, slug, hammer, strike, impact, back, outlet, discharge, exhaust, temperature, pressure, superheat, overheat, time, period, stop, close, off, shutdown, condenser, compressor, centre, middle, medium

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2009109126 A (DAIKIN KOGYO KK), 21 May 2009 (21.05.2009), description, paragraphs [0043]-[0055] and [0090]-[0103], and figures 3, 4 and 11	1-3, 5-10, 12-14
Y	JP 2009109126 A (DAIKIN KOGYO KK), 21 May 2009 (21.05.2009), description, paragraphs [0043]-[0055] and [0090]-[0103], figures 3, 4 and 11	4, 11
Y	JP 2001065949 A (MATSUSHITA DENKI SANGYO KK), 16 March 2001 (16.03.2001), description, paragraphs [0061] and [0091], and figures 2, 6 and 8	4, 11
PX	CN 106403429 A (GUANGDONG MIDEA HEATING & VENTILATION EQUIPMENT CO., LTD. et al.), 15 February 2017 (15.02.2017), claims 1-11	1-3, 5-6, 8-10, 12-14
PX	CN 106766444 A (GUANGDONG MIDEA HEATING & VENTILATION EQUIPMENT CO., LTD. et al.), 31 May 2017 (31.05.2017), claims 1-9	1-4, 6, 8-11, 13-14
A	CN 202056042 U (YANTAI TONGDA REFRIGERATION EQUIPMENT CO., LTD.), 30 November 2011 (30.11.2011), entire document	1-14
A	CN 105509255 A (GUANGDONG MIDEA HEATING & VENTILATION EQUIPMENT CO., LTD. et al.), 20 April 2016 (20.04.2016), entire document	1-14

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

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search

14 August 2017

Date of mailing of the international search report

15 September 2017

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/089642

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

10

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	CN 103307818 A (TCL AIR CONDITIONER (ZHONGSHAN) CO., LTD.), 18 September 2013 (18.09.2013), entire document	1-14
A	JP S6414554 A (HITACHI LTD.), 18 January 1989 (18.01.1989), entire document	1-14

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/089642

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CN 106403429 A	15 February 2017	None	
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CN 105509255 A	20 April 2016	None	
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Form PCT/ISA/210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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