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

(11) EP 4 556 807 A1

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

(43) Date of publication:
21.05.2025 Bulletin 2025/21

(21) Application number: 23839035.5

(22) Date of filing: 13.07.2023

(51) International Patent Classification (IPC):
F24F 11/61 (2018.01) *F24F 11/56* (2018.01)
F24F 11/83 (2018.01) *F24F 140/20* (2018.01)

(52) Cooperative Patent Classification (CPC):
F24F 11/56; F24F 11/61; F24F 11/83; F24F 2140/20

(86) International application number:
PCT/CN2023/107322

(87) International publication number:
WO 2024/012545 (18.01.2024 Gazette 2024/03)

(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: 13.07.2022 CN 202210822346
21.07.2022 CN 202210867618

(71) Applicant: **Qingdao Hisense Hitachi Air-Conditioning Systems Co., Ltd.**
Qingdao, Shandong 266555 (CN)

(72) Inventors:
- **SHI, Jingfeng**
  Qingdao, Shandong 266555 (CN)
- **REN, Zhaoting**
  Qingdao, Shandong 266555 (CN)
- **LU, Zefeng**
  Qingdao, Shandong 266555 (CN)
- **CHEN, Jianxing**
  Qingdao, Shandong 266555 (CN)
- **RUAN, Daiwei**
  Qingdao, Shandong 266555 (CN)
- **SHENG, Kai**
  Qingdao, Shandong 266555 (CN)
- **JIAO, Xiaolong**
  Qingdao, Shandong 266555 (CN)

(74) Representative: **Petraz, Gilberto Luigi et al**
GLP S.r.l.
Viale Europa Unita, 171
33100 Udine (IT)

(54) AIR CONDITIONING SYSTEM AND METHOD FOR DETERMINING ENERGY EFFICIENCY RATIO THEREOF

(57) Disclosed are an air conditioning system and a method for determining the energy efficiency ratio thereof. The air conditioning system includes a water chilling unit and a controller. The controller is configured for using a first temperature sensor to obtain a first condensation temperature of a condenser in an n-th detection period, and using a second temperature sensor to obtain a first evaporation temperature of an evaporator in the n-th detection period; according to the operating parameters of the water chilling unit, determining a second condensation temperature of the condenser in the n-th detection period and a second evaporation temperature of the evaporator in the n-th detection period; according to the first condensation temperature and the first evaporation temperature, determining a first energy efficiency ratio in the n-th detection period; according to the second condensation temperature and the second evaporation temperature, determining a second energy efficiency ratio in the n-th detection period; and according to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period, determining an ideal energy efficiency ratio in the n-th detection period.

EP 4 556 807 A1

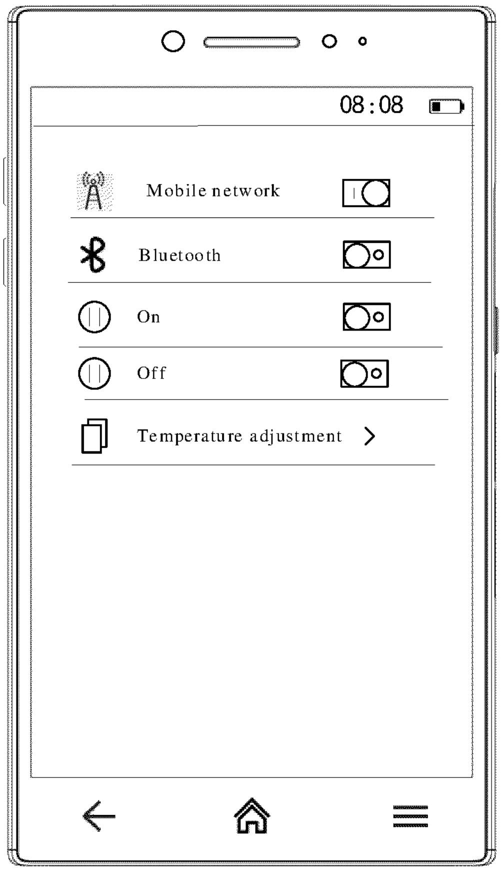
08:08
Mobile network
Bluetooth
On
Off
Temperature adjustment

FIG. 5

Description

[0001] This application claims priority to Chinese Patent Application No. CN202210822346.4 filed on July 13, 2022 and Chinese Patent Application No. CN202210867618.2 filed on July 21, 2022, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates to the field of air conditioning technologies, and in particular, to an air conditioning system and a method for determining the energy efficiency ratio thereof.

BACKGROUND

[0003] A central air conditioning system is widely used in public buildings, a water chilling unit is one of main energy consumption devices of the central air conditioning system, the operating performance of the water chilling unit is influenced by a plurality of factors, the energy efficiency of the water chilling unit is greatly influenced by a cooling load, and the operating performance of the water chilling unit can be improved by reasonably adjusting and controlling an operating strategy of the water chilling unit according to the cooling load.

SUMMARY

[0004] In a first aspect, an air conditioning system is provided, and the air conditioning system includes a water chilling unit, a refrigerant circulation loop, a first temperature sensor, a second temperature sensor, and a controller. The refrigerant circulation loop is configured for circulating a refrigerant in a loop including a compressor, a condenser, and an evaporator. The first temperature sensor is configured for detecting a condensation temperature of the condenser. The second temperature sensor is configured for detecting an evaporation temperature of the evaporator. The controller is configured for: using the first temperature sensor to obtain a first condensation temperature in an n-th detection period, and using the second temperature sensor to obtain a first evaporation temperature in the n-th detection period, n being an integer greater than 1; obtaining operating parameters of the water chilling unit, and based on the operating parameters, determining a second condensation temperature of the condenser in the n-th detection period and a second evaporation temperature of the evaporator in the n-th detection period; determining a first energy efficiency ratio in the n-th detection period according to the first condensation temperature and the first evaporation temperature; determining a second energy efficiency ratio in the n-th detection period according to the second condensation temperature and the second evaporation temperature; and determining an ideal energy efficiency ratio in the n-th detection period according to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period.

[0005] In a second aspect, a method for determining the energy efficiency ratio of an air conditioning system is provided, the air conditioning system includes a water chilling unit, and the method is applied to the water chilling unit. The method includes: using a first temperature sensor to obtain a first condensation temperature of a condenser in an n-th detection period, and using a second temperature sensor to obtain a first evaporation temperature of an evaporator in the n-th detection period, n being an integer greater than 1; obtaining operating parameters of the water chilling unit, and based on the operating parameters, determining a second condensation temperature of the condenser in the n-th detection period and a second evaporation temperature of the evaporator in the n-th detection period; determining a first energy efficiency ratio in the n-th detection period according to the first condensation temperature and the first evaporation temperature; determining a second energy efficiency ratio in the n-th detection period according to the second condensation temperature and the second evaporation temperature; and determining an ideal energy efficiency ratio in the n-th detection period according to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period.

[0006] In a third aspect, an air conditioning system is provided, and the air conditioning system includes: an evaporator, a condenser, and a controller. The controller is configured for: obtaining an evaporation temperature of the air conditioning system, a condensation temperature of the air conditioning system, a first energy efficiency ratio of the air conditioning system, and a load ratio of the air conditioning system according to operating data of the evaporator and the condenser in a preset duration; obtaining a second energy efficiency ratio of the air conditioning system and a first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system according to the evaporation temperature of the air conditioning system, the condensation temperature of the air conditioning system, the first energy efficiency ratio of the air conditioning system, and the load ratio of the air conditioning system; obtaining a second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system by using a back propagation neural network model; and obtaining a third corresponding relationship between a target energy efficiency ratio of the air conditioning system and the load ratio of the air conditioning system by using the first corresponding relationship and the second corresponding relationship based on a mean clustering algorithm.

[0007] In a fourth aspect, a method for controlling an air conditioning system is provided, including: obtaining an evaporation temperature of the air conditioning system, a condensation temperature of the air conditioning system, a first energy efficiency ratio of the air conditioning system, and a load ratio of the air conditioning system according to operating data of an evaporator and a condenser in a preset duration; obtaining a second energy efficiency ratio of the air conditioning system and a first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system according to the evaporation temperature of the air conditioning system, the condensation temperature of the air conditioning system, the first energy efficiency ratio of the air conditioning system, and the load ratio of the air conditioning system; obtaining a second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system by using a back propagation neural network model; and obtaining a third corresponding relationship between a target energy efficiency ratio of the air conditioning system and the load ratio of the air conditioning system by using the first corresponding relationship and the second corresponding relationship based on a mean clustering algorithm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic structural diagram of a water chilling unit according to some embodiments of the present application;
FIG. 2 is a schematic structural diagram of another water chilling unit according to some embodiments of the present application;
FIG. 3 is a block diagram of a hardware configuration of a water chilling unit according to some embodiments of the present application;
FIG. 4 is a schematic interaction diagram of a controller of a water chilling unit and a terminal device according to some embodiments of the present application;
FIG. 5 is a schematic diagram of a management interface of a water chilling unit according to some embodiments of the present application;
FIG. 6 is a schematic flowchart of a method for determining an energy efficiency ratio of an air conditioning system according to some embodiments of the present application;
FIG. 7 is a schematic flowchart of another method for determining an energy efficiency ratio of an air conditioning system according to some embodiments of the present application;
FIG. 8 is a schematic flowchart of another method for determining an energy efficiency ratio of an air conditioning system according to some embodiments of the present application;
FIG. 9 is a schematic flowchart of another method for determining an energy efficiency ratio of an air conditioning system according to some embodiments of the present application;
FIG. 10 is a schematic flowchart of another method for determining an energy efficiency ratio of an air conditioning system according to some embodiments of the present application;
FIG. 11 is a schematic flowchart of a method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 12 is a schematic flowchart of another method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 13 is a schematic flowchart of yet another method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 14 is a schematic flowchart of yet another method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 15 is a schematic flowchart of yet another method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 16 is a schematic flowchart of yet another method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 17 is a schematic flowchart of yet another method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 18 is a schematic flowchart of yet another method for controlling an air conditioning system according to some embodiments of the present application;
FIG. 19 is a structural diagram of a neural network of a model for predicting the performance of a water chilling unit according to some embodiments of the present application; and
FIG. 20 is a schematic diagram of a hardware structure of a controller according to some embodiments of the present application.

DETAILED DESCRIPTION

[0009] Some embodiments of the present disclosure are clearly and completely described below with reference to the accompanying drawings, and apparently, the described embodiments are not all but only a part of the embodiments of the present disclosure. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present disclosure shall fall within the protection scope of the present disclosure.

[0010] Unless required otherwise in the context, throughout the specification and the claims, the term "comprise" and its other forms such as "comprises" and "comprising" are interpreted as open and inclusive meaning "including, but not limited to". In the description of the specification, the terms "one embodiment", "some embodiments", "exemplary embodiments", "example", "specific example", "some examples", or the like, are intended to indicate that a particular feature, structure, material, or characteristic related to the embodiment or example is included in at least one embodiment or example of the present disclosure. The schematic representations of the above terms do not necessarily refer to the same embodiment or example. In addition, the particular feature, structure, material, or characteristic may be included in any suitable manner in any one or more embodiments or examples.

[0011] The use of "adapted to" or "configured for" herein means open and inclusive languages and does not exclude devices adapted to or configured for performing additional tasks or steps.

[0012] Additionally, since a process, step, calculation, or other action that is "based on" one or more stated conditions or values may, in practice, be based on additional conditions or exceed the stated values, the use of "based on" is open and inclusive.

[0013] The operating performance of a water chilling unit may be improved by adjusting an operating strategy of the water chilling unit according to a cooling load, so that the higher the accuracy of the determined cooling load is, the greater the benefit for improving the operating performance of the water chilling unit is. Currently, the cooling load is determined according to the energy efficiency ratio of the water chilling unit, and in the related art, the energy efficiency ratio of the water chilling unit is determined only according to a condensation temperature of a condenser and an evaporation temperature of an evaporator in the water chilling unit detected by temperature sensors. However, in the operating process of the water chilling unit, the temperature sensor is easily affected by various measurement noises, abnormal values or system errors, resulting in a low accuracy of the detected condensation temperature of the condenser and the detected evaporation temperature of the evaporator, , which in turn leading to a low accuracy of the cooling load determined according to the inaccuracy condensation temperature of the condenser and the evaporation temperature of the evaporator, and therefore, the operating strategy of the water chilling unit cannot be reasonably regulated and controlled, thus affecting the operating performance of the water chilling unit.

[0014] Based on this, some embodiments of the present application provide a method for determining the energy efficiency ratio of an air conditioning system, and the air conditioning system includes a water chilling unit. On the one hand, a detected value of an evaporation temperature of an evaporator and a detected value of a condensation temperature of a condenser are obtained through temperature sensors, and then, a detected value of the energy efficiency ratio is determined according to the detected value of the evaporation temperature and the detected value of the condensation temperature. On the other hand, a calculated value of an evaporation temperature of the evaporator and a calculated value of a condensation temperature of the condenser are determined according to the operating parameters of the water chilling unit, and then, a calculated value of the energy efficiency ratio is determined according to the calculated value of the evaporation temperature and the calculated value of the condensation temperature. Then, according to the detected value of the energy efficiency ratio and the calculated value of the energy efficiency ratio, different energy efficiency ratios are selected as ideal energy efficiency ratios under different conditions, which can minimize the influences of the abnormity of the temperature sensor on the determination of the ideal energy efficiency ratio as much as possible, thus enhancing the reasonability and accuracy of the determination of the ideal energy efficiency ratio. Further, when the cooling load of the water chilling unit is determined according to the ideal energy efficiency ratio with high accuracy, the cooling load with high accuracy can be obtained, thus improving the accuracy of the determined cooling load of the water chilling unit.

[0015] FIG. 1 shows a schematic structural diagram of a water chilling unit in an exemplary embodiment of the present application. It should be noted that the water chilling unit in some embodiments of the present application may include different types of water chilling units such as an air-cooled water chilling unit and a water-cooled water chilling unit. The water chilling unit may be further classified into a screw water chilling unit, a vortex water chilling unit, a centrifugal water chilling unit, or the like, according to the type of a compressor. For convenience of description, different types of water chilling units are illustrated by using the schematic structural diagram of the water chilling unit shown in FIG. 1 as an example.

[0016] As shown in FIG. 1, the water chilling unit 1 includes a compressor 10, a condenser 11, a throttling member 12, an evaporator 13, and a controller 14 (see FIG. 3). The compressor 10, the condenser 11, the throttling member 12, and the evaporator 13 are sequentially connected to form a refrigerant circulation loop. It should be noted that, in some embodiments of the present application, the sequential connection only illustrates the sequential relationship of the connections between the devices, and other devices may also be included between the devices. For example, as shown in

FIG. 2, a stop valve 15, or the like, may be arranged on a pipeline between the compressor 10 and the condenser 11.

[0017] During cooling, the compressor 10 compresses low-temperature and low-pressure refrigerant gas into high-temperature and high-pressure refrigerant gas, and discharges the high-temperature and high-pressure refrigerant gas to the condenser 11. The high-temperature and high-pressure refrigerant gas exchanges heat with outdoor air flow in the condenser 11, a refrigerant releases heat, the released heat is brought to outdoor ambient air by the air flow, and the refrigerant then undergoes a phase change to be condensed into a liquid or a mixture of gas and liquid refrigerant. The refrigerant flows out of the condenser 11, enters the throttling member 12 to be cooled and depressurized into low-temperature and low-pressure refrigerant. The low-temperature and low-pressure refrigerant enters the evaporator 13, and the refrigerant absorbs heat of chilled water in the evaporator 13 to lower the temperature of the chilled water in the evaporator 13, so as to achieve the cooling effect. The refrigerant undergoes a phase change to be evaporated into low-temperature and low-pressure refrigerant gas, and the low-temperature and low-pressure refrigerant gas flows back into the compressor 10, so that the refrigerant is recycled. The evaporator 13 in the present embodiment is also connected to a user side, and after the temperature of the chilled water in the evaporator 13 is lowered, the chilled water enters the user side, and the chilled water in the evaporator 13 can be replenished from the user side.

[0018] In some embodiments, the chilled water in the water chilling unit 1 enters the evaporator 13 and absorbs cold energy evaporated by the refrigerant, the temperature of the chilled water is lowered, and the chilled water becomes cold water which enters a water separator, then enters a surface cooler or a cooling coil, exchanges heat with the treated air, and then returns to the water chilling unit 1 for recycling treatment.

[0019] In some embodiments, the water chilling unit 1 further includes cooling water (also called cooling liquid). During the operating process of the water chilling unit 1, a large amount of heat may be brought by operation of the components, and if the heat is not taken away in time, high-temperature components are easily damaged by the excessive temperature. By utilizing the effect of heat conduction, when the cooling water flows through the high-temperature component, the heat is conducted into the cooling water from the high-temperature component, the water temperature rises, and the heat can be continuously taken away by the continuous cooling water, so as to cool the high-temperature component.

[0020] In some embodiments, the heat exchange of the water chilling unit 1 includes four processes: (1) heat exchange between the chilled water and air in an occasion where cooling is required. (2) Heat exchange between the chilled water and the refrigerant in the evaporator. (3) Heat exchange between the cooling water and the refrigerant in the condenser. (4) Heat exchange between the cooling water and air in a cooling tower.

[0021] In some embodiments, the compressor 10 may be a screw compressor.

[0022] In some embodiments, a plurality of compressors 10 may be provided, and the plurality of compressors are connected in parallel.

[0023] In some embodiments, the evaporator 13 may be a flooded evaporator or a falling film evaporator.

[0024] In some embodiments, the throttling member 12 may be an electronic expansion valve, a capillary tube, or the like.

[0025] In some embodiments, the controller 14 is an apparatus capable of generating an operation control signal according to an instruction operation code and a timing signal, and instructing the multi-split air conditioning system to execute a control instruction. For example, the controller may be a central processing unit (CPU), a general-purpose processor, a network processor (NP), a digital signal processor (DSP), a microcontroller unit (MCU), or any combination thereof.

[0026] In addition, the controller 14 can be configured for controlling the components in the water chilling unit 1 to work, so as to cause the components of the water chilling unit 1 to operate to achieve predetermined functions of the water chilling unit 1.

[0027] In some embodiments, the controller 14 can obtain electric power and a cooling load ratio of the water chilling unit 1 during operation of the water chilling unit 1.

[0028] In some embodiments, the controller 14 can calculate the cooling load ratio of the water chilling unit according to a real-time load value of the water chilling unit 1 and a rated load value of the water chilling unit 1. That is, a ratio of the real-time load value to the rated load value is used as the cooling load ratio.

[0029] FIG. 3 shows a block diagram of a hardware configuration of a water chilling unit in an exemplary embodiment of the present application, as shown in FIG. 3.

[0030] In some embodiments, the water chilling unit 1 may include a first temperature sensor 21, and the first temperature sensor 21 may be arranged around the condenser 11 and configured for detecting a condensation temperature of the condenser 11.

[0031] In some embodiments, the water chilling unit 1 may include a second temperature sensor 22, and the second temperature sensor 22 may be arranged around the evaporator 13 and configured for detecting an evaporation temperature of the evaporator 13.

[0032] In some embodiments, the water chilling unit 1 may include a third temperature sensor 23, and the third temperature sensor 23 may be arranged on a chilled water supply pipeline of the water chilling unit 1 and configured for detecting a supply water temperature value of the chilled water.

[0033] In some embodiments, the water chilling unit 1 may include a fourth temperature sensor 24, and the fourth temperature sensor 24 may be arranged on a chilled water return pipeline of the water chilling unit 1 and configured for detecting a return water temperature value of the chilled water.

[0034] In some embodiments, the controller 14 may determine a temperature difference between supply water temperature and return water temperature of the chilled water according to the supply water temperature value of the chilled water detected by the third temperature sensor 23 and the return water temperature value of the chilled water detected by the fourth temperature sensor 24.

[0035] In some embodiments, the water chilling unit 1 may include a fifth temperature sensor 25, and the fifth temperature sensor 25 may be arranged on a cooling water supply pipeline of the water chilling unit 1 and configured for detecting a supply water temperature value of the cooling water.

[0036] In some embodiments, the water chilling unit 1 may include a sixth temperature sensor 26, and the sixth temperature sensor 26 may be arranged on a cooling water return pipeline of the water chilling unit 1 and configured for detecting a return water temperature value of the cooling water.

[0037] In some embodiments, the controller 14 may determine a temperature difference between the supply water temperature and return water temperature of the cooling water according to the supply water temperature value of the cooling water detected by the fifth temperature sensor 25 and the return water temperature value of the cooling water detected by the sixth temperature sensor 26.

[0038] In some embodiments, in order to improve the accuracy of the determined energy efficiency ratio, the temperature difference between supply water temperature and return water temperature of the chilled water and the temperature difference between supply water temperature and return water temperature of the cooling water when the water chilling unit 1 operates at full load may be obtained.

[0039] In some embodiments, the water chilling unit 1 may include a seventh temperature sensor 27, and the seventh temperature sensor 27 may be arranged at a water outlet of the water chilling unit 1 and configured for detecting an outlet water temperature of the water chilling unit 1.

[0040] In some embodiments, the controller 14 may determine a heat exchange temperature difference of the condenser 11 according to the condensation temperature of the condenser 11 detected by the first temperature sensor 21 and the outlet water temperature detected by the seventh temperature sensor 27. The heat exchange temperature difference of the condenser 11 is configured for representing a heat exchange performance of the condenser 11.

[0041] In some embodiments, the water chilling unit 1 may include an eighth temperature sensor 27, and the eighth temperature sensor 27 may be arranged on the evaporator 13 and configured for detecting an environment temperature of an environment in which the evaporator 13 is located. The environment in which the evaporator 13 is located may be the atmosphere or other fluids.

[0042] In some embodiments, the controller 14 may determine a heat exchange temperature difference of the evaporator 13 according to the evaporation temperature of the evaporator 13 detected by the second temperature sensor 22 and the environment temperature detected by the eighth temperature sensor 28. The heat exchange temperature difference of the evaporator 13 is configured for representing a heat exchange performance of the evaporator 13.

[0043] In some embodiments, the water chilling unit 1 may include a communicator 29 configured for establishing a communication connection with other network entities such as a terminal device.

[0044] In some embodiments, the water chilling unit 1 may include a memory 30 configured for storing software programs and data. The controller 14 executes various functions of the water chilling unit 1 and data processing by executing the software programs or data stored in the memory 30.

[0045] FIG. 4 shows a schematic interaction diagram of the controller of a water chilling unit and a terminal device in some embodiments of the present application. As shown in FIG. 4, the terminal device 300 can establish a communication connection with the controller 14. Exemplarily, the establishment of the communication connection may be realized using any known network communication protocol. It should be noted that the terminal device 300 shown in FIG. 4 is only one example of the terminal device. The terminal device 300 in the present application may be a remote controller, a mobile phone, a tablet computer, a personal computer (PC), a personal digital assistant (PDA), or the like, and the specific form of the terminal device is not specifically limited in the present application.

[0046] Exemplarily, when the terminal device 300 is a mobile phone, a user may download a water chilling unit management APP on the mobile phone, and the water chilling unit management APP may be configured for managing the water chilling unit. The user can select the water chilling unit 1, which is an online device, and select a control function required to be performed on the water chilling unit 1 from management options of the water chilling unit 1. Exemplarily, FIG. 5 shows a schematic diagram of a management interface of a water chilling unit in an exemplary embodiment of the present application, and the management options of the water chilling unit 1 displayed on the water chilling unit management APP may include control functions such as startup, shutdown, and temperature adjustment. If it is detected that the user clicks the startup option of the water chilling unit 1 in the water chilling unit management APP, the mobile phone can send a startup instruction to the water chilling unit 1. In response to the startup instruction, the controller controls the components in the water chilling unit to start working.

[0047] As shown in FIG. 6, some embodiments of the present application provide a method for determining the energy efficiency ratio of an air conditioning system, the method may be applied to the controller 14 of the above water chilling unit 1, and the method includes the following steps.

[0048] In S101: a first condensation temperature of the condenser in an n-th detection period is obtained through the first temperature sensor, and a first evaporation temperature of the evaporator in the n-th detection period is obtained through the second temperature sensor.

[0049] In some embodiments, in the operating process of the water chilling unit, after the controller receives a control instruction for determining a cooling load issued by a user, in response to the control instruction for determining the cooling load, the controller uses the first temperature sensor to obtain the first condensation temperature of the condenser in the n-th detection period, and uses the second temperature sensor to obtain the first evaporation temperature of the evaporator in the n-th detection period, where n is a positive integer, e.g., 20. The detection period may be preset when the water chilling unit is manufactured, or may be set by a manager of the water chilling unit through a terminal device. For example, one detection period is 5 seconds and is not limited herein.

[0050] The n-th detection period may be understood as a current detection period, and n-1 detection periods before the n-th detection period may be understood as historical detection periods before the current detection period.

[0051] In some embodiments, the detection period may be a time point. That is, the first condensation temperature of the condenser at the current time point and the first evaporation temperature of the evaporator at the current time point are obtained.

[0052] It is easy to understand that the first condensation temperature and the first evaporation temperature are both detected by the corresponding temperature sensors, the first condensation temperature can be understood as a detected value of a condensation temperature of the condenser, and the first evaporation temperature can be understood as a detected value of an evaporation temperature of the evaporator.

[0053] In some embodiments, during the operating process of the water chilling unit, the controller can periodically use the first temperature sensor to obtain the first condensation temperature of the condenser in the n-th detection period and use the second temperature sensor to obtain the first evaporation temperature of the evaporator in the n-th detection period, so as to determine the ideal energy efficiency ratio of the water chilling unit timely, then determine the cooling load of the water chilling unit timely, and then adjust an operating strategy of the water chilling unit timely according to the cooling load of the water chilling unit, which facilitates the improvement of the operating performance of the water chilling unit.

[0054] Exemplarily, the first condensation temperature of the condenser in the n-th detection period may be denoted as T_{c1}, and the first evaporation temperature of the evaporator in the n-th detection period may be denoted as T_{e1}.

[0055] In S102: operating parameters of the water chilling unit are obtained, and based on the operating parameters, a second condensation temperature of the condenser in the n-th detection period and a second evaporation temperature of the evaporator in the n-th detection period are determined.

[0056] It should be understood that the operating parameters of the water chilling unit are parameters generated by the components of the water chilling unit during the operating process of the water chilling unit. With one detection period as a unit, the operating parameters of the water chilling unit include a temperature difference between supply water temperature and return water temperature of chilled water, a temperature difference between the supply water temperature and return water temperature of cooling water, a heat exchange temperature difference of the evaporator, a heat exchange temperature difference of the condenser, a supply water temperature of the chilled water, a return water temperature of the cooling water, a cooling load ratio of the water chilling unit, electric power of the water chilling unit, or the like.

[0057] It should be noted that, in order to improve the accuracy of subsequent determination of the ideal energy efficiency ratio, values of the operating parameters of the water chilling unit are all obtained from values of the water chilling unit in a fully-loaded state.

[0058] In some embodiments, as shown in FIG. 7, determining the second condensation temperature of the condenser in the n-th detection period and the second evaporation temperature of the evaporator in the n-th detection period based on the operating parameters may include the following steps S1021 and S1022.

[0059] In S1021: the second condensation temperature of the condenser in the n-th detection period is determined according to the temperature difference between the supply water temperature and return water temperature of the cooling water in the n-th detection period, the heat exchange temperature difference of the condenser in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period.

[0060] Exemplarily, the relationship between the temperature difference between the supply water temperature and return water temperature of the cooling water in the n-th detection period, the heat exchange temperature difference of the condenser in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period and the second condensation temperature of the condenser in the n-th detection period may be shown in the following formula (1):

$$T_{c2} = T_{c-rtn} + \frac{1}{2} * PLR * T_{c-em} + PLR * T_{c-exc} \qquad (1)$$

where T_{c2} is the second condensation temperature of the condenser in the n-th detection period, PLR is the cooling load ratio of the water chilling unit in the n-th detection period, $T_{c\text{-}rtn}$ is the return water temperature of the cooling water in the n-th detection period, and $T_{c\text{-}exc}$ is the heat exchange temperature difference of the condenser in the n-th detection period.

[0061] In S 1022: the second evaporation temperature of the evaporator in the n-th detection period is obtained according to the temperature difference between the supply water temperature and return water temperature of the chilled water in the n-th detection period, the heat exchange temperature difference of the evaporator in the n-th detection period, the supply water temperature of the chilled water in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period.

[0062] Exemplarily, the relationship between the temperature difference between the supply water temperature and return water temperature of the chilled water in the n-th detection period, the heat exchange temperature difference of the evaporator in the n-th detection period, the supply water temperature of the chilled water in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period and the second evaporation temperature of the evaporator in the n-th detection period may be shown in the following formula (2):

$$T_{e2} = T_{e-sup} + \frac{1}{2} * PLR * T_{e-em} + PLR * T_{c-exc} \qquad (2)$$

where T_{e2} is the second evaporation temperature of the evaporator in the n-th detection period, $T_{e\text{-}sup}$ is the supply water temperature of the chilled water in the n-th detection period, $T_{e\text{-}em}$ is the temperature difference between supply water temperature and return water temperature of the chilled water in the n-th detection period, and $T_{c\text{-}exc}$ is the heat exchange temperature difference of the evaporator in the n-th detection period.

[0063] It is easy to understand that the second condensation temperature can be understood as a calculated value of the condensation temperature of the condenser, and the second evaporation temperature can be understood as a calculated value of the evaporation temperature of the evaporator.

[0064] In S103: a first energy efficiency ratio in the n-th detection period is determined according to the first condensation temperature and the first evaporation temperature.

[0065] In some embodiments, the first energy efficiency ratio may be represented as a COP (coefficient of performance) and refers to the amount of cooling produced per unit of power consumed. After the first condensation temperature of the condenser in the n-th detection period and the first evaporation temperature of the evaporator in the n-th detection period are obtained, the first energy efficiency ratio in the n-th detection period may be determined according to the first condensation temperature of the condenser in the n-th detection period and the first evaporation temperature of the evaporator in the n-th detection period.

[0066] Exemplarily, the relationship between the first condensation temperature, the first evaporation temperature, and the first energy efficiency ratio may be shown in the following formula (3):

$$K_1 = \frac{T_{e1}}{T_{c1} - T_{e1}} \qquad (3)$$

where K_1 is the first energy efficiency ratio in the n-th detection period.

[0067] In S104: a second energy efficiency ratio in the n-th detection period is determined according to the second condensation temperature and the second evaporation temperature.

[0068] In some embodiments, after the second condensation temperature of the condenser in the n-th detection period is obtained through step S1021 and the second evaporation temperature of the evaporator in the n-th detection period is obtained through step S1022, the second energy efficiency ratio in the n-th detection period may be determined according to the second condensation temperature of the condenser in the n-th detection period and the second evaporation temperature of the evaporator in the n-th detection period.

[0069] Exemplarily, the relationship between the second condensation temperature, the second evaporation temperature, and the second energy efficiency ratio may be shown in the following formula (4):

$$K_2 = \frac{T_{e2}}{T_{c2} - T_{e2}} \qquad (4)$$

where K_2 is the second energy efficiency ratio in the n-th detection period.

[0070] It should be noted that the execution order of step S103 and step S104 is not limited in some embodiments of the present application. For example, step S103 is executed first, and step S104 is then executed. Alternatively, step S104 is executed first, and step S103 is then executed. Still alternatively, step S103 and step S104 are executed simultaneously.

[0071] In S105: an ideal energy efficiency ratio in the n-th detection period is determined according to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period.

[0072] It is easy to understand that the first energy efficiency ratio is obtained according to the first condensation temperature and the first evaporation temperature, and the first condensation temperature and the first evaporation temperature are detected by the temperature sensors, so that the first energy efficiency ratio can be understood as a detected value of the energy efficiency ratio. The second energy efficiency ratio is obtained according to the second condensation temperature and the second evaporation temperature, and the second condensation temperature and the second evaporation temperature are calculated according to the operating parameters of the water chilling unit, so that the second energy efficiency ratio can be understood as a calculated value of the energy efficiency ratio.

[0073] Then, the detected value of the energy efficiency ratio or the calculated value of the energy efficiency ratio can be selected as the ideal energy efficiency ratio in different situations. This approach, compared to the related art in which only the detected value of the energy efficiency ratio is used as the ideal energy efficiency ratio, can avoid the influences of abnormity of the temperature sensor on the determination of the ideal energy efficiency ratio, thereby improving the reasonability and accuracy of the determination of the ideal energy efficiency ratio.

[0074] Compared to the related art in which the ideal energy efficiency ratio is determined only according to the detected value of the condensation temperature of the condenser and the detected value of the evaporation temperature of the evaporator detected by the temperature sensors, in the method for determining the energy efficiency ratio of an air conditioning system according to some embodiments of the present application, the ideal energy efficiency ratio in the n-th detection period is determined by comparing the detected value of the energy efficiency ratio with the calculated value of the energy efficiency ratio, so that influences of an error of the temperature sensor on the accuracy of the ideal energy efficiency ratio can be reduced, and the reasonability and accuracy of the determination of the ideal energy efficiency ratio are improved. Further, by determining the cooling load of the water chilling unit according to the ideal energy efficiency ratio with high accuracy, the cooling load with high accuracy can be obtained, thus improving the accuracy of the determined cooling load of the water chilling unit.

[0075] In some embodiments, as shown in FIG. 8, an implementation of step S105 may include the following steps.

[0076] In S201: the ideal energy efficiency ratio in the n-th detection period is determined according to the first energy efficiency ratio in the n-th detection period, the second energy efficiency ratio in the n-th detection period, a first value range, and a second value range.

[0077] The first value range is determined according to an average value and a standard deviation of the first energy efficiency ratios in n detection periods, and the second value range is determined according to an average value and a standard deviation of the second energy efficiency ratios in the n detection periods.

[0078] A manner of determining the first energy efficiency ratio in each of the n detection periods can be referred to the description of the above step S103, and a manner of determining the second energy efficiency ratio in each of the n detection periods reference can be referred to the description of the above step S104, which are not repeated herein.

[0079] Exemplarily, the average value of the first energy efficiency ratios in the n detection periods may be as shown in the following formula (5):

$$\overline{K_1} = \frac{\sum_{i=1}^{n} K_{1_i}}{n} \qquad (5)$$

where $\overline{K_1}$ is the average value of the first energy efficiency ratios in the n detection periods, and K_{1_i} is the first energy efficiency ratio in the i-th detection period among the n detection periods.

[0080] Exemplarily, the standard deviation of the first energy efficiency ratios in the n detection periods may be as shown in the following formula (6):

$$\sigma_1 = \sqrt{\frac{\sum_{i=1}^{n} (K_{1_i} - \overline{K_1})^2}{n}} \qquad (6)$$

where σ_1 is the standard deviation of the first energy efficiency ratios in the n detection periods.

[0081] Exemplarily, the average value of the second energy efficiency ratios in the n detection periods may be as shown in the following formula (7):

$$\overline{K_2} = \frac{\sum_{i=1}^{n} K_{2_i}}{n} \qquad (7)$$

where $\overline{K_2}$ is the average value of the second energy efficiency ratios in the n detection periods, and K_{2_i} is the second energy efficiency ratio in the i-th detection period among the n detection periods.

[0082] Exemplarily, the standard deviation of the second energy efficiency ratios in the n detection periods may be as shown in the following formula (8):

$$\sigma_2 = \sqrt{\frac{\sum_{i=1}^{n}(K_{2i}-\overline{K_2})^2}{n}} \qquad (8)$$

where σ_2 is the standard deviation of the second energy efficiency ratios in the n detection periods.

[0083] In some embodiments, the first value range and the second value range may be preset by the manager of the water chilling unit according to an operating condition of the water chilling unit and stored in the memory.

[0084] In some embodiments, the first value range and the second value range may alternatively be calculated by the controller in real time according to a preset rule and the operating parameters of the water chilling unit. For example, the first value range may be $(\overline{K_1}-\sigma_1, \overline{K_1}+\sigma_1)$, and the second value range may be $(\overline{K_2}-\sigma_1, \overline{K_2}+\sigma_1)$. For another example, the first value range may be $(\overline{K_1}-2\sigma_1, \overline{K_1}+2\sigma_1)$, the second value range may be $(\overline{K_2}-2\sigma_1, \overline{K_2}+2\sigma_1)$, and setting ranges of the first value range and the second value range are not limited in some embodiments of the present application.

[0085] In some embodiments, as shown in FIG. 9, an implementation of step S201 may include the following steps.

[0086] In S2011: when the first energy efficiency ratio in the n-th detection period is not within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, an average value of the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period is taken as the ideal energy efficiency ratio in the n-th detection period.

[0087] It can be understood that, when the first energy efficiency ratio in the n-th detection period is not within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, neither the first energy efficiency ratio nor the second energy efficiency ratio can effectively reflect the ideal energy efficiency ratio in the n-th detection period, so that the average value of the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period is used as the ideal energy efficiency ratio in the n-th detection period. Compared to the related technologies where the energy efficiency ratio is determined according to the evaporation temperature and the condensation temperature detected by the sensors, this approach enhances the rationality and accuracy of determining the ideal energy efficiency ratio.

[0088] In S2012: when the first energy efficiency ratio in the n-th detection period is within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, the first energy efficiency ratio in the n-th detection period is taken as the ideal energy efficiency ratio in the n-th detection period.

[0089] It can be understood that when the first energy efficiency ratio in the n-th detection period is within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, it indicates that errors of the temperature sensors are small, and the first condensation temperature of the condenser and the first evaporation temperature of the evaporator detected by the corresponding temperature sensors are accurate. That is to say, a calculation result of the first energy efficiency ratio is better than a calculation result of the second energy efficiency ratio, and the first energy efficiency ratio can better reflect the ideal energy efficiency ratio in the n-th detection period than the second energy efficiency ratio, so that the first energy efficiency ratio in the n-th detection period is taken as the ideal energy efficiency ratio in the n-th detection period.

[0090] In S2013: when the second energy efficiency ratio in the n-th detection period is within the second value range, the second energy efficiency ratio in the n-th detection period is taken as the ideal energy efficiency ratio in the n-th detection period.

[0091] As can be seen from the above description, the second energy efficiency ratio is calculated according to the operating parameters of the water chilling unit, and when it is detected that the second energy efficiency ratio is within the second value range, the second energy efficiency ratio can better reflect the ideal energy efficiency ratio in the n-th detection period, so that the second energy efficiency ratio in the n-th detection period is taken as the ideal energy efficiency ratio in the n-th detection period.

[0092] Exemplarily, a value of the ideal energy efficiency ratio in the n-th detection period under different conditions may be as shown in the following formula (9):

$$K_F = \begin{cases} \frac{K_1+K_2}{2}, K_1 \notin \left(\overline{K_1}-\sigma_1,\ \overline{K_1}+\sigma_1\right) \text{且} K_2 \notin \left(\overline{K_2}-\sigma_2,\ \overline{K_2}+\sigma_2\right) \\ K_1,\ K_1 \in \left(\overline{K_1}-\sigma_1,\ \overline{K_1}+\sigma_1\right) \text{且} K_2 \notin \left(\overline{K_2}-\sigma_2,\ \overline{K_2}+\sigma_2\right) \\ K_2,\ K_2 \in \left(\overline{K_2}-\sigma_2,\ \overline{K_2}+\sigma_2\right) \end{cases} \qquad (9)$$

where K_F is the ideal energy efficiency ratio in the n-th detection period.

[0093] Exemplarily, the following table 1 provides some values of K_1, K_2, $\overline{K_1}$, $\overline{K_2}$, σ_1, σ_2, and K_F in the exemplary embodiment of the present application.

Table 1

Detection period	K_1	K_2	$\overline{K_1}$	$\overline{K_2}$	σ_1	σ_2	K_F
1	0.6754	0.6765	0.6754	0.6765	0.0000	0.0000	0.6760
2	0.6500	0.6533	0.6627	0.6649	0.0090	0.0082	0.6516
3	0.6577	0.6628	0.6611	0.6642	0.0076	0.0068	0.6603
4	0.6394	0.6228	0.6556	0.6538	0.0104	0.0166	0.6311
5	0.6312	0.6430	0.6508	0.6516	0.0128	0.0153	0.6371
6	0.6268	0.6337	0.6468	0.6487	0.0142	0.0153	0.6303
7	0.6501	0.6537	0.6472	0.6494	0.0132	0.0142	0.6519
8	0.6244	0.6507	0.6444	0.6496	0.0143	0.0133	0.6375
9	0.6364	0.6007	0.6435	0.6441	0.0136	0.0192	0.6186
10	0.6402	0.6660	0.6432	0.6463	0.0130	0.0192	0.6531

[0094] The above embodiment emphasizes the manner for determining the ideal energy efficiency ratio in the n-th detection period. In some embodiments, the method for determining the energy efficiency ratio of an air conditioning system according to some embodiments of the present application further involves usage of the ideal energy efficiency ratio. As shown in FIG. 10, after step S105, the method further includes the following steps.

[0095] In S301: the cooling load of the water chilling unit in the n-th detection period is determined according to the electric power of the water chilling unit in the n-th detection period, the cooling load ratio of the water chilling unit in the n-th detection period and the ideal energy efficiency ratio in the n-th detection period.

[0096] For example, the relationship between the electric power of the water chilling unit in the n-th detection period, the cooling load ratio of the water chilling unit in the n-th detection period, the ideal energy efficiency ratio in the n-th detection period, and the cooling load of the water chilling unit in the n-th detection period may be as shown in the following formula (10):

$$Q_i = (a * PLR^2 + b * PLR + c) * K_F * P_W \qquad (10)$$

where Q_i is the cooling load of the water chilling unit in the n-th detection period, PLR is the cooling load ratio of the water chilling unit in the n-th detection period, P_W is the electric power of the water chilling unit in the n-th detection period, and a, b, and c are all constants.

[0097] Here, a, b, and c are obtained by performing training based on data of the water chilling unit, data training is to collect operating data of the water chilling unit for a period of time, use PLR as the horizontal axis, use a ratio of the energy efficiency ratio (the coefficient of performance, COP) of the water chilling unit to K_F as the vertical axis, and perform curve fitting on the data to obtain a, b and c.

[0098] The relationship between the COP and K_F may be as shown in the following formula (11):

$$DCOP = \frac{COP}{K_F} \qquad (11).$$

[0099] The embodiment shown in FIG. 9 brings at least the following beneficial effects: compared to the related art in which the ideal energy efficiency ratio of the water chilling unit is obtained according to the condensation temperature and the evaporation temperature detected by the temperature sensors, the method for determining the energy efficiency ratio of an air conditioning system according to some embodiments of the present application not only determines the first energy efficiency ratio of the water chilling unit according to the first condensation temperature and the first evaporation temperature detected by the temperature sensors, but also determines the second condensation temperature and the second evaporation temperature according to the operating parameters of the water chilling unit, then determines the second energy efficiency ratio of the water chilling unit, and selects different energy efficiency ratios as the ideal energy efficiency ratio of the water chilling unit under different conditions, thereby reducing the influences of the errors of the temperature sensors on the accuracy of the determination of the ideal energy efficiency ratio, and improving the reasonability and accuracy of the determination of the ideal energy efficiency ratio. Then, the cooling load of the water chilling unit is determined according to the ideal energy efficiency ratio with high accuracy, thus improving the accuracy of the determination of the cooling load of the water chilling unit.

[0100] In addition, in the method for determining the energy efficiency ratio of an air conditioning system according to some embodiments of the present application, when determining the cooling load of the water chilling unit according to the ideal energy efficiency ratio, the electric power of the water chilling unit is introduced to serve as a determination basis of the cooling load of the water chilling unit. It can be understood that, compared to the electric power of the water chilling unit, the temperature detected by the temperature sensor has a delay and error to a certain extent and is also easily influenced by various noises. In contrast, detection of the electric power of the water chilling unit is more stable, so that the accuracy and stability of the determination of the cooling load of the water chilling unit are improved by taking the electric power of the water chilling unit as one of bases for calculating the cooling load of the water chilling unit.

[0101] Further, the manager of the water chilling unit adjusts the operating strategy of the water chilling unit according to the cooling load with higher accuracy, and the accuracy of the adjustment of the operating strategy is higher, which facilitates the improvement of the operating performance of the water chilling unit.

[0102] Based on the above air conditioning system, as shown in FIG. 11, some embodiments of the present application provide a method for controlling an air conditioning system, and the method may include the following steps.

[0103] S111: the air conditioning system obtains an evaporation temperature of the air conditioning system, a condensation temperature of the air conditioning system, a first energy efficiency ratio of the air conditioning system, and a load ratio of the air conditioning system according to operating data of the evaporator and the condenser in a preset duration.

[0104] In some embodiments, the operating data includes a supply chilled water temperature, a return chilled water temperature, a chilled water flow rate, and an evaporator evaporation temperature of the evaporator, a supply cooling water temperature, a return cooling water temperature, a cooling water flow rate, and a condenser condensation temperature of the condenser, and a water chilling unit load ratio, water chilling unit power of the air conditioning system, or the like.

[0105] In some embodiments, the preset duration may be half a year, one year, or the like, the operating data corresponding to each time point in the preset duration may form one data set, and a time interval for obtaining the operating data may be 5 minutes, 10 minutes, or the like. For example, one data set is acquired every 5 minutes, and one data set may include the supply chilled water temperature, the return chilled water temperature, the chilled water flow rate, and the evaporator evaporation temperature of the evaporator, the supply cooling water temperature, the return cooling water temperature, the cooling water flow rate, and the condenser condensation temperature of the condenser, and the water chilling unit load ratio, the water chilling unit power, or the like, of the air conditioning system at this time point.

[0106] S112: the air conditioning system obtains a second energy efficiency ratio and a first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system according to the evaporation temperature, the condensation temperature, and the first energy efficiency ratio.

[0107] In some embodiments, the second energy efficiency ratio is a DCOP (dynamic coefficient of performance), and also represents an internal energy efficiency of the air conditioning system, which mainly reflects a deviation between a COP and an ICOP (ideal coefficient of performance), and the DCOP can be used to determine a reason for a low operating efficiency of the air conditioning system.

[0108] In some embodiments, the first corresponding relationship may be an air conditioning system DCOP performance model established between the DCOP of the air conditioning system and a PLR (part load ratio) of the air conditioning system. Since the first corresponding relationship is obtained or established based on actual operating data, the DCOP performance model correspondingly represented by the first corresponding relationship can reflect a real energy efficiency of the air conditioning system.

[0109] S113: the air conditioning system obtains a second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system by using a back propagation neural network model.

[0110] In some embodiments, the second corresponding relationship may be an air conditioning system DCOP performance prediction model established between the DCOP of the air conditioning system and the PLR of the air conditioning system. Since the second corresponding relationship is established through learning and prediction of a back propagation neural network, the energy efficiency of the air conditioning system can be predicted by the DCOP performance prediction model correspondingly represented by the second corresponding relationship.

[0111] In some embodiments, the back propagation neural network model has a BP (back propagation) neural network structure, and the BP neural network is a multi-layer feedforward neural network trained according to an error back propagation algorithm.

[0112] In some embodiments, the water chilling unit load ratio of the air conditioning system and a temperature difference between the evaporation temperature and the condensation temperature of the air conditioning system in the operating data may be input into the back propagation neural network model to obtain the second energy efficiency ratio and the second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system.

[0113] Exemplarily, the BP neural network structure is established, and has three layers. Input neurons of the neural network are the water chilling unit load ratio, and the difference between the condensation temperature and the evaporation temperature. The number of network nodes of a network hidden layer is seven. An output neuron is the DCOP. A trainlm (Levenberg-Marquarelt) learning algorithm is used in the BP neural network model, a network hidden layer transfer function is a tansig function (bipolar S function), an output layer is a Pureline function (linear function), a learning rate of the BP neural network model can be set to be 0.05, a maximum number of learning steps can be set to be 1,000, and a training target error can be set to be 0.003, so that the above DCOP prediction model can be obtained through data training.

[0114] S114: the air conditioning system obtains a third corresponding relationship between a target energy efficiency ratio of the air conditioning system and the load ratio of the air conditioning system by using the first corresponding relationship and the second corresponding relationship based on a mean clustering algorithm.

[0115] In some embodiments, the third corresponding relationship represents a target performance model of the air conditioning system that can realize the target energy efficiency ratio.

[0116] In some embodiments, the mean clustering algorithm is a K-means clustering algorithm. The K-means algorithm is a classic distance-based clustering algorithm, and a distance is used as an evaluation index of similarity. That is, the closer the two objects are, the greater the similarity of the two objects is.

[0117] In some embodiments, the establishment of the third corresponding relationship according to the first corresponding relationship means that the performance of an operating state of the air conditioning system at a current time is predicted according to the DCOP performance model established by using the real operating data of the air conditioning system, and the performance can be represented by the target energy efficiency ratio; the establishment of the third corresponding relationship according to the second corresponding relationship means that the performance of the operating state of the air conditioning system at the current time is predicted according to the DCOP performance prediction model of the air conditioning system established by the BP neural network, and the performance can be represented by the target energy efficiency ratio.

[0118] According to the operating data of the evaporator and the condenser within the preset duration, the first energy efficiency ratio and the second energy efficiency ratio of the air conditioning system are obtained, and then, the first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system is established. Then, the second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system is predicted through the back propagation neural network model. Whether the third corresponding relationship is established according to the first corresponding relationship or the second corresponding relationship is then determined based on the mean clustering algorithm. In the control method according to the present application, the plurality of corresponding relationships between the energy efficiency ratio of the air conditioning system and the load ratio of the air conditioning system can be obtained in different ways, and the more appropriate corresponding relationship is selected from the corresponding relationships to determine the target energy efficiency ratio. A more accurate cooling capacity can be determined according to the target energy efficiency ratio, thereby lowering operating energy consumption of the air conditioning system. In addition, the prediction precision of the energy efficiency ratio of the air conditioning system can be improved, and the problem that the precision of prediction of the energy efficiency ratio by the performance model of the air conditioning system in the related art is low is solved. Meanwhile, premises are provided for energy consumption simulation, energy efficiency monitoring and formulation of a reasonable energy-saving control strategy of the air conditioning system.

[0119] In some embodiments, a first performance ratio, the evaporation temperature, and a cooling temperature of the air conditioning system may be further obtained by obtaining a water chilling unit direct load and a water chilling unit cooling amount. Therefore, as shown in FIG. 12, the step S111 may include the following steps.

[0120] In S211, the water chilling unit direct load is obtained according to a specific heat capacity of water and the chilled water flow rate, the return chilled water temperature, and the supply chilled water temperature in a target data set in the operating data.

[0121] In some embodiments, the water chilling unit direct load may be obtained using formula (12):

$$Q_{\mathrm{d}} = c \cdot m_{\mathrm{e}} \cdot (T_{\text{e-rtn}} - T_{\text{e-sup}}) \qquad (12)$$

where Q_d represents the water chilling unit direct load, c represents the specific heat capacity of water, m_e represents the chilled water mass flow rate, $T_{e\text{-}rtn}$ represents the return chilled water temperature, and $T_{e\text{-}sup}$ represents the supply chilled water temperature.

[0122] In S212: the water chilling unit cooling amount is obtained according to the specific heat capacity of water and the cooling water flow rate, the return cooling water temperature, and the supply cooling water temperature in the target data set in the operating data.

[0123] In some embodiments, the water chilling unit cooling amount may be obtained using formula (13):

$$Q_c = c \cdot m_c \cdot (T_{c\text{-sup}} - T_{c\text{-rtn}}) \qquad (13)$$

where Q_c represents the water chilling unit cooling amount, m_c represents the cooling water flow rate, $T_{c\text{-sup}}$ represents the supply cooling water temperature, and $T_{c\text{-rtn}}$ represents the return cooling water temperature.

[0124] In some embodiments, in consideration of an error in time measurement, a load unbalance ratio can be obtained according to the water chilling unit power, the water chilling unit direct load, and the water chilling unit cooling amount. Under the condition that the load unbalance ratio is greater than or equal to a preset load unbalance ratio, the data set corresponding to the load unbalance ratio in the operating data is deleted, so as to reduce an error of data acquisition. Exemplarily, the load unbalance ratio may be calculated using formula (14):

$$B_a = \frac{\left|Q_c - (Q_d + P_w)\right|}{Q_c} \qquad (14)$$

where B_a represents the load unbalance ratio, and P_w represents the water chilling unit power.

[0125] Exemplarily, the preset load unbalance ratio may be 15%. That is, when the load unbalance ratio calculated according to some data in one data set is greater than or equal to 15%, all data in the data set corresponding to the load unbalance ratio is removed from the operating data.

[0126] In the above embodiment, the data set in the operating data corresponding to the abnormal load unbalance ratio is removed, so that interference of the abnormal data set in the establishment of the performance model of the air conditioning system is reduced, the data set in the operating data is more accurate, and a foundation is laid for the subsequent improvement of the precision of the model of the air conditioning system.

[0127] In some embodiments, as shown in FIG. 13, removing the data set corresponding to an abnormal data value of the first energy efficiency ratio may include the following steps.

[0128] In S311, the first energy efficiency ratio of the air conditioning system is obtained according to the water chilling unit direct load and the water chilling unit power in the target data set in the operating data.

[0129] In some embodiments, the water chilling unit cooling amount may be obtained using formula (15):

$$COP = \frac{Q_d}{P_w} \qquad (15)$$

where the COP represents the first energy efficiency ratio.

[0130] In S312, the data in the target data set is deleted from the operating data under the condition that the first energy efficiency ratio is outside a preset interval.

[0131] Exemplarily, the preset interval may be ($\mu 1$-$2\sigma 1$, $\mu 1$+$2\sigma 1$), $\mu 1$ is an average value of the COPs in a current month and $\sigma 1$ is a standard deviation of the COPs in the current month. That is, when a value of the COP is outside the interval ($\mu 1$-$2\sigma 1$, $\mu 1$+$2\sigma 1$), the value is an abnormal value, and all the data in the target data set corresponding to the value of the COP is removed from the operating data.

[0132] In the above embodiment, when the first energy efficiency ratio is outside the preset interval, the data set in the operating data corresponding to the first energy efficiency ratio is deleted. In this embodiment, the data set in the operating data corresponding to the abnormal first energy efficiency ratio is removed, so that the interference of the abnormal data set in the establishment of the performance model of the air conditioning system is reduced, the data in the operating data is more accurate, and the foundation is laid for the subsequent improvement of the precision of the model of the air conditioning system.

[0133] In some embodiments, as shown in FIG. 14, obtaining the evaporation temperature of the air conditioning system may include the following steps.

[0134] In S411, an evaporator logarithmic mean temperature difference corresponding to the target data set is obtained according to a temperature difference between the supply chilled water temperature and the evaporator evaporation temperature in the target data set and a temperature difference between the return chilled water temperature and the evaporator evaporation temperature in the target data set.

[0135] In some embodiments, the evaporator logarithmic mean temperature difference may be obtained using formulas (16) and (17):

$$\Delta t_{m,e} = \frac{\Delta t_{e2} - \Delta t_{e1}}{\ln \frac{\Delta t_{e2}}{\Delta t_{e1}}} \quad (16)$$

$$\Delta t_{ch,e} = \Delta t_{e2} - \Delta t_{e1} \quad (17)$$

where Δt_{e2} and Δt_{e1} represent the temperature difference between the supply chilled water temperature and the evaporator evaporation temperature and the temperature difference between the return chilled water temperature and the evaporator evaporation temperature, respectively, $\Delta t_{m,e}$ represents the evaporator logarithmic mean temperature difference, and $\Delta t_{ch,e}$ represents a temperature difference between inlet and outlet of the evaporator.

[0136] In S412, an evaporator heat transfer coefficient corresponding to the target data set is obtained according to the water chilling unit direct load and the evaporator logarithmic mean temperature difference.

[0137] In some embodiments, the evaporator heat transfer coefficient may be obtained using formula (18):

$$K_e F_e = \frac{Q_\mathrm{d}}{\Delta t_{m,e}} \quad (18)$$

where K_eF_e represents the evaporator heat transfer coefficient.

[0138] In S413, an evaporator target heat transfer coefficient is obtained by performing fitting according to the evaporator heat transfer coefficients corresponding to different data sets.

[0139] In some embodiments, the evaporator target heat transfer coefficient may be obtained by performing regression fitting using formula (19):

$$K_e F_e = a_1 m_e^2 + b_1 m_e \cdot Q_d + c_1 Q_d^2 + d_1 m_e + e_1 Q_d + f_1 \quad (19)$$

where a_1, b_1, c_1, d_1, e_1 and f_1 represent parameters of a fitted evaporator model.

[0140] In some embodiments, by obtaining the evaporator target heat transfer coefficient by performing the regression fitting, the evaporation temperature of the air conditioning system can be quantitatively depicted in a curve mode, so that the evaporation temperature of the air conditioning system is more comprehensive and accurate.

[0141] In S414, the evaporation temperature of the air conditioning system is obtained according to a density of water, the specific heat capacity of water, the evaporator target heat transfer coefficient, the water chilling unit direct load, the chilled water flow rate, and the supply chilled water temperature.

[0142] In some embodiments, the evaporation temperature of the air conditioning system may be obtained using formula (20):

$$T_e = T_{e\text{-sup}} - \frac{Q_d}{\rho c m_e \left(\exp\left(\frac{K_e F_e}{\rho c m_e} \right) - 1 \right)} \quad (20)$$

where ρ represents the density of water, and T_e represents the evaporation temperature.

[0143] In the above embodiment, the evaporator target heat transfer coefficient is obtained by performing fitting based on the evaporator heat transfer coefficients corresponding to different data sets in the operating data, which can help to establish a heat transfer model of the evaporator, so that obtained evaporation temperature data of the air conditioning system is more comprehensive and accurate.

[0144] In some embodiments, as shown in FIG. 15, obtaining the condensation temperature of the air conditioning system may include the following steps.

[0145] In S511, a condenser logarithmic mean temperature difference corresponding to the target data set is obtained according to a temperature difference between the supply cooling water temperature and the condenser condensation temperature in the target data set and a temperature difference between the return cooling water temperature and the condenser condensation temperature in the target data set.

[0146] In some embodiments, the condenser logarithmic mean temperature difference may be obtained using formulas (21) and (22):

$$\Delta t_{m,c} = \frac{\Delta t_{c2} - \Delta t_{c1}}{\ln\dfrac{\Delta t_{c2}}{\Delta t_{c1}}} \tag{21}$$

$$\Delta t_{ch,c} = \Delta t_{c2} - \Delta t_{c1} \tag{22}$$

where Δt_{c2} represents the temperature difference between a supply cooling water temperature and the condenser condensation temperature, Δt_{c1} represents the temperature difference between the return cooling water temperature and the condenser condensation temperature, $\Delta t_{m,c}$ represents the condenser logarithmic mean temperature difference, and $\Delta t_{ch,c}$ represents a temperature difference the inlet and outlet of the condenser.

[0147] In S512, a condenser heat transfer coefficient corresponding to the target data set is obtained according to the water chilling unit direct load and the condenser logarithmic mean temperature difference.

[0148] In some embodiments, the condenser heat transfer coefficient may be obtained using formula (23):

$$K_c F_c = \frac{Q_c}{\Delta t_{m,c}} \tag{23}$$

where K_cF_c represents the condenser heat transfer coefficient.

[0149] In S513, a condenser target heat transfer coefficient is obtained by performing fitting based on the condenser heat transfer coefficients corresponding to different data sets.

[0150] In some embodiments, the condenser target heat transfer coefficient may be obtained by performing fitting using formula (24):

$$K_c F_c = a_2 m_c^2 + b_2 m_c \cdot Q_c + c_2 Q_c^2 + d_2 m_c + e_2 Q_c + f_2 \tag{24}$$

where a_2, b_2, c_2, d_2, e_2 and f_2 represent parameters of a fitted condenser model.

[0151] In some embodiments, by obtaining the condenser target heat transfer coefficient by performing the regression fitting, the condensation temperature of the air conditioning system can be quantitatively depicted in a curve mode, so that the condensation temperature of the air conditioning system is more comprehensive and accurate.

[0152] In S514, the condensation temperature of the air conditioning system is obtained according to the density of water, the specific heat capacity of water, the condenser target heat transfer coefficient, the water chilling unit direct load, the cooling water flow rate, and the return cooling water temperature.

[0153] In some embodiments, the condensation temperature of the air conditioning system may be obtained using formula (25):

$$T_c = T_{c\text{-rtn}} + \frac{Q_c}{\rho c m_c \left(\exp\left(\dfrac{K_c F_c}{\rho c m_c} \right) - 1 \right)} \tag{25}$$

where ρ represents the density of water, and T_c represents the condensation temperature.

[0154] In the above embodiment, the condenser target heat transfer coefficient is obtained by performing fitting according to the condenser heat transfer coefficients corresponding to different data sets in the operating data, which can help to establish a heat transfer model of the condenser, so that obtained condensation temperature data of the air conditioning system is more comprehensive and accurate.

[0155] In some embodiments, the first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system may be a first corresponding relationship of the air conditioning system represented by a curve. Therefore, as shown in FIG. 16, the step S112 may include the following steps.

[0156] In S611, with the second energy efficiency ratio as an abscissa and the load ratio corresponding to the second energy efficiency ratio as an ordinate, a scatter diagram composed of a plurality of data points is generated.

[0157] In some embodiments, a value of the ICOP of the air conditioning system may be calculated using formula (26), and a value of the DCOP may be calculated using formula (27):

$$ICOP = \frac{T_e}{T_c - T_e} \quad (26)$$

$$DCOP = \frac{COP}{ICOP} \quad (27)$$

where the ICOP represents the ideal energy efficiency ratio, and the DCOP represents the second energy efficiency ratio.

[0158] In some embodiments, the value of the DCOP may be used as the abscissa, and the water chilling unit load ratio PLR corresponding to the value of the DCOP may be used as the ordinate, so as to generate the scatter diagram composed of the plurality of data points, and the scatter diagram may visually represent a relationship between the value of the DCOP of the air conditioning system and the load ratio PLR corresponding thereto.

[0159] In S602: the first corresponding relationship represented by the curve is obtained by fitting the data points on the scatter diagram.

[0160] In some embodiments, the obtained first corresponding relationship represented by the curve may be the air conditioning system DCOP performance model established by performing regression fitting on the data. Exemplarily, the regression fitting may be performed using formula (28) to identify and obtain model coefficients, so as to obtain the air conditioning system DCOP performance model:

$$DCOP = A \cdot PLR^2 + B \cdot PLR + C \quad (29)$$

where the PLR is the water chilling unit load ratio; A, B, and C are parameters of the fitted model of the air conditioning system.

[0161] In the above embodiment, the air conditioning system DCOP performance model curve obtained based on the large amount of actual operating data is one of bases for optimizing operation of the air conditioning system, and with the air conditioning system DCOP performance model obtained by data regression fitting, construction of the performance model of the air conditioning system is more complete, so that the air conditioning system DCOP performance model can be selectively suitable for air conditioning systems in different actual environments, thus improving prediction precision of the energy efficiency ratio of the air conditioning system.

[0162] In some embodiments, the third corresponding relationship of the air conditioning system may be obtained by selectively using the first corresponding relationship or the second corresponding relationship according to data similarity between a newly added current data set and the target data set in the operating data. Therefore, as shown in FIG. 17, the step S114 may include the following steps.

[0163] In S711, the data similarity between the current data set and the target data set in the operating data is obtained based on the water chilling unit load ratio and the temperature difference between the evaporation temperature and the condensation temperature of the air conditioning system.

[0164] The current data set includes operating data obtained after the preset duration, and may also represent operating data at the current time.

[0165] In some embodiments of the present application, the target data set may represent any data set in the operating data. In some embodiments, input data may be clustered by using a K-means clustering analysis method, and an optimal number k of clustering centers is found in a preset interval by using an elbow method, so as to obtain the clustering centers p_1, p_2, ..., and p_k. Exemplarily, the water chilling unit load ratio and the temperature difference between the evaporation temperature and the condensation temperature are clustered by using the K-means clustering analysis method, and the optimal number k of the clustering centers is found in the interval [2,10] by using the elbow method, so as to obtain the clustering centers p_1, p_2, ..., and p_k. Then, Euclidean distances d_1, d_2, ..., and d_k from the water chilling unit load ratio and the temperature difference between the evaporation temperature and the condensation temperature to the clustering centers are calculated by using formula (29):

$$d_i = \sqrt{\sum_{j=1}^{n}(x_j - p_i)^2} \; (i = 1,2,\ldots,k) \quad (29)$$

where x_j is an n-dimensional input parameter, p_i is the clustering center, and d_i is the Euclidean distance from the input parameter to the clustering center p_i.

[0166] In some embodiments, the data similarity may be data proximity, and the data similarity between the current data set and the target data set in the operating data may be calculated using formula (30):

$$I = \frac{\max(d_i) - \min(d_i)}{\max(d_i) + \min(d_i)} (i = 1, 2, \ldots k) \qquad (30)$$

where I is the data similarity between the current data set and the target data set in the operating data.

[0167] In S712, the third corresponding relationship is established according to the first corresponding relationship under the condition that the data similarity is smaller than or equal to preset similarity; and the third corresponding relationship is established according to the second corresponding relationship under the condition that the data similarity is greater than the preset similarity.

[0168] In some embodiments, the established third corresponding relationship may also represent a target performance model of the air conditioning system. The target performance model may be obtained using formula (31) to obtain the target energy efficiency ratio from the target performance model.

$$COP = ICOP \cdot DCOP \qquad (31)$$

[0169] The COP in the formula (31) may represent the target energy efficiency ratio.

[0170] In some embodiments, the current data set may include the water chilling unit operating load ratio, the condensation temperature of the air conditioning system, and the evaporation temperature of the air conditioning system in the operating data obtained after the preset duration. The data of the target data set in the operating data is input neurons in the BP neural network: the water chilling unit load ratio, and the difference between the condensation temperature and the evaporation temperature. Similarity between the current input data and the input neuron in the BP neural network can be calculated by using the formula (19), I' (preset similarity) is taken as a boundary, and when the similarity is higher than I', the current data set is close to the input neuron in the BP neural network, so that the air conditioning system DCOP performance prediction model established by using the BP neural network is selected to establish the target performance model of the air conditioning system. When the similarity is smaller than or equal to I', the precision of prediction by using the air conditioning system DCOP performance model is higher, so that the air conditioning system DCOP performance model is selected to establish the target performance model of the air conditioning system. In the above embodiment, data similarity between a first data set and the current data set is obtained through the mean clustering algorithm, and whether the first corresponding relationship or the second corresponding relationship is used to establish the third corresponding relationship is determined according to the similarity, so that the establishment of the performance model of the air conditioning system is based on an actual situation of the current data, the prediction precision of the model of the air conditioning system is improved, and the more accurate target energy efficiency ratio and cooling capacity can be obtained, so as to achieve efficient, safe and energy-saving operating targets of the air conditioning system.

[0171] The control method according to some embodiments of the present application is described below by taking a centrifugal water chilling unit with a rated cooling capacity of 440kW as an example. The compressor is a centrifugal compressor, the evaporator and the condenser are both shell-and-tube heat exchangers, water flows in tubes, a refrigerant R134a flows outside the tubes, and an electronic expansion valve is used. As shown in FIG. 18, steps for establishing the performance model of the water chilling unit are as follows.

[0172] In S811of collecting data by sensors: a large amount of actual operating data of the water chilling unit is collected through the sensors, and operating data of ten features in a certain year is obtained: a supply chilled water temperature, a return chilled water temperature, a water chilling unit cooling load ratio, water chilling unit power, a chilled water flow rate, a supply cooling water temperature, a return cooling water temperature, a cooling water flow rate, an evaporator evaporation temperature, and a condenser condensation temperature.

[0173] In S812 of performing data screening: data screening is performed by taking all data of continuous months as a set of operating data.

1) Calculating a load unbalance ratio: a water chilling unit direct load is calculated by using the formula (12), a water chilling unit cooling mount is calculated by using the formula (13), and then, the load unbalance ratio is calculated by using the formula (14).
2) calculating a COP of the water chilling unit: the water chilling unit direct load is calculated using the formula (12), and then, the COP of the water chilling unit is calculated using the formula (15).
3) performing data removal.

[0174] A rule for identifying an abnormal unbalance ratio is as follows:
when the unbalance ratio exceeds 15%, the unbalance ratio is an abnormal value, that is, when the load unbalance ratio calculated at a certain time point is greater than or equal to 15%, a data set at the time point corresponding to the load unbalance ratio is removed from the operating data.

[0175] A rule for identifying an abnormal COP value is as follows:
when the COP value is outside the interval (μ1-2σ1, μ1+2σ1), the value is an abnormal value and is removed, μ1 is an average value of the COPs in a current month, and σ1 is a standard deviation of the COPs in the current month. That is, when the COP value calculated at a time point is outside the interval (μ1-2σ1, μ1+2σ1), the COP value is an abnormal value, and a data set at the time point corresponding to the COP value is removed from the operating data.

[0176] In S813, an evaporation temperature and a condensation temperature are calculated by using the data values that has been screened.

1) Calculating the evaporation temperature: a temperature difference between the supply chilled water temperature and the evaporator evaporation temperature and a temperature difference between the return chilled water temperature and the evaporator evaporation temperature are calculated, an evaporator logarithmic mean temperature difference and a temperature difference between inlet and outlet of the evaporator are calculated through the formulas (15) and (17) respectively, and then, an evaporator heat transfer coefficient K_eF_e is calculated by utilizing the formula (18). The evaporator heat transfer coefficient is subjected to regression fitting by using the formula (19), the evaporator heat transfer coefficient K_eF_e is quantitatively depicted, and the evaporation temperature is calculated by using the formula (20). The calculated regression fitting coefficient is shown in table 2 below.

Table 2. Calculation results of fitting coefficients for evaporator heat transfer model

a_1	b_1	c_1	d_1	e_1	f_1
-3.30E+01	-4.80E-03	-3.14E-04	5.01E+03	6.75E-01	-190311.015

2) Calculating the condensation temperature: a temperature difference between the return cooling water temperature and the condenser condensation temperature and a temperature difference between a supply cooling water temperature and the condenser condensation temperature are calculated, a condenser logarithmic mean temperature difference and a temperature difference between inlet and outlet of the condenser are calculated through the formulas (21) and (22) respectively, a condenser heat transfer coefficient K_cF_c is then calculated by using the formula (23), the condenser heat transfer coefficient is subjected to regression fitting by using the formula (24), the condenser heat transfer coefficient K_cF_c is quantitatively depicted, and the condensation temperature is calculated by using the formula (25). The calculated regression fitting coefficient is shown in table 3 below.

Table 3. Calculation results of fitting coefficients for condenser heat transfer model

a_2	b_2	c_2	d_2	e_2	f_2
-3.65E-01	-1.11E-02	-2.39E-04	6.94E+01	1.26E+00	-3227.177731

[0177] In S814, a DCOP performance model of the water chilling unit is established.

[0178] The evaporation temperature and the condensation temperature of the water chilling unit are calculated through the formulas (20) and (25), an ideal COP value of the water chilling unit is calculated through the formula (26) and is defined as an ICOP value, and a DCOP value is calculated through the formula (27), the DCOP value is a degree of the actual COP value of the water chilling unit approaching the ideal COP value, which is called a water chilling unit performance coefficient. Finally, a load ratio PLR is taken as an abscissa, the water chilling unit performance coefficient DCOP is take as an ordinate, and corresponding data points are listed in a coordinate system to form a dense scatter diagram. Regression fitting is then performed through the formula (28) to identify and obtain a model coefficient, so as to obtain a water chilling unit DCOP performance model. The calculated regression fitting coefficients and corresponding model evaluation indexes are shown in table 4 below.

Table 4. Calculation results of fitting coefficients for DCOP performance model

A	B	C
-0.6578	0.8922	0.3294
MAPE (mean absolute percentage error)	RMSE (root mean square error)	R^2 (determination coefficient)
1.2663%	0.0108	0.7490

[0179] Newly added water chilling unit operating data is input into the trained DCOP performance model for calculation, so as to obtain model error evaluation indexes shown in the following table 5.

Table 5. DCOP performance model newly added data error evaluation index

MAPE (mean absolute percentage error)	RMSE (root mean square error)	R^2 (determination coefficient)
1.4828%	0.0185	0.7325

[0180] For input data which is not trained by the model, a prediction result of the DCOP performance model is still close to an actual measurement result, and the generalization capacity of the DCOP performance model is good.

[0181] In S815, a DCOP performance prediction model of the water chilling unit is established through a BP neural network model.

[0182] A BP neural network structure is established and has three layers, as shown in FIG. 19, and input neurons of a neural network are the operating load ratio PLR of the water chilling unit and the difference T_c-T_e between the condensation temperature and the evaporation temperature. The number of network nodes of a network hidden layer is 7. An output neuron is a DCOP. A trainlm learning algorithm is used in the BP neural network model, a network hidden layer transfer function is a tansig function, an output layer is a Pureline function, a learning rate of the BP neural network model is set to be 0.05, a maximum number of learning steps is set to be 1,000, and a training target error is set to be 0.003, so that the DCOP prediction model of the water chilling unit is obtained through data training.

[0183] Through calculation, training data error evaluation indexes for the DCOP prediction result and the DCOP actual measurement calculation result are shown in table 6. Newly added water chilling unit operating data is input into the trained DCOP prediction model for calculation, so as to obtain model error evaluation indexes shown in the following table 7. It can be seen that the DCOP performance prediction model established by the neural network has higher precision, but when the newly added input data deviates from training data of the model, an error is reduced, which indicates that the generalization capacity of the model is poor.

Table 6. DCOP prediction model training data error evaluation index

MAPE (mean absolute percentage error)	RMSE (root mean square error)	R^2 (determination coefficient)
0.6043%	0.0059	0.9073

Table 7. DCOP prediction model newly added data error evaluation index

MAPE (mean absolute percentage error)	RMSE (root mean square error)	R^2 (determination coefficient)
2.0949%	0.0182	0.6492

[0184] In S816, the DCOP performance model and the COP performance prediction model of the water chilling unit are fused based on a K-means clustering algorithm, and the water chilling unit model is established.

1) Performing clustering to obtain clustering centers: the input data of the DCOP prediction model is clustered by using a K-means clustering analysis method, and an optimal number k of the clustering centers is found in the interval [2, 10] by using an elbow method to obtain the clustering centers p_1, p_2, ..., and p_k. In this embodiment, the number k of the clustering centers calculated through the elbow method is 5, and Euclidean distances d_1, d_2, ..., and d_k from input parameters to the clustering centers are calculated through the formula (18). Coordinates of the clustering centers p_1, p_2, p_3, p_4, p_5, p_6 and p_7 are shown in table 8.

Table 8. Clustering center calculation result

Clustering center 1	Clustering center 2	Clustering center 3	Clustering center 4
(0.673, 29.412)	(0.841, 32.571)	(0.588, 26.479)	(0.461, 22.689)
Clustering center 5	Clustering center 6	Clustering center 7	
(0.676, 30.819)	(0.638, 28.014)	(0.609, 24.835)	

2) Calculating clustering center proximity I by using the newly added data.

3) Taking I' (preset similarity) as a boundary, where when the proximity is higher than I', the current data set is close to the input neuron in the BP neural network, so that the air conditioning system DCOP performance prediction model established by using the BP neural network is selected; when the proximity is less than or equal to I', the precision of prediction by using the air conditioning system DCOP performance model established by using parameter identification is higher, so that the air conditioning system DCOP performance model established by using the parameter identification is

selected. In this embodiment, I' is 0.8. Newly added data error evaluation indexes are shown in table 9.

Table 9. Water chilling unit model newly added data error evaluation index

MAPE (mean absolute percentage error)	RMSE (root mean square error)	R^2 (determination coefficient)
1.6328%	0.0133	0.8362

4) Constructing the water chilling unit performance model.

[0185] The energy efficiency ratio COP of the water chilling unit is calculated by using the formula (20). Newly added data error evaluation indexes are shown in table 10. Therefore, the finally established water chilling unit model has higher prediction precision, and a generalization capacity and a self-adaption capacity of the model are also better.

Table 10. Water chilling unit model COP prediction error evaluation index

MAPE (mean absolute percentage error)	RMSE (root mean square error)	R^2 (determination coefficient)
1.6318%	0.1553	0.8735

[0186] As can be seen from the above examples, in the control method according to some embodiments of the present application, the evaporation temperature and the condensation temperature of the water chilling unit can be quantitatively depicted in the curve manner by counting the actual energy efficiency ratios of the water chilling unit under different weather conditions and different cooling load ratios, the ideal energy efficiency ratios in various situations, the target heat transfer coefficients of the evaporator and the target heat transfer coefficients of the condenser of the water chilling unit. Based on a physical framework of the water chilling unit, the actual performance model of the water chilling unit is established by using the actual data, the water chilling unit performance prediction model is then established through the BP neural network, and finally, the actual performance model of the water chilling unit is combined with the high-precision prediction interval of the performance prediction model by using the K-means clustering method to obtain the water chilling unit target performance model. The target performance model obtained by the solution is completely based on the actual data, so that the actual performance of the water chilling unit under different load ratios can be well reflected, the prediction precision of the water chilling unit model is greatly improved, and the problems that a traditional water chilling unit performance curve cannot be applied to actual projects, and an existing water chilling unit performance model is not high in prediction precision and poor in self-adaptation capacity and universality are solved. The target energy efficiency ratio can be obtained according to the target performance model, so that a more reasonable and more accurate cooling capacity can be determined according to the target energy efficiency ratio, thus effectively lowering operating energy consumption of the water chilling unit.

[0187] In some embodiments of the present application, functional modules of the controller may be divided according to the above method examples. For example, each functional module may be divided corresponding to each function, or two or more functions may be integrated into one processing module. The integrated module can be realized in the form of hardware or a software functional module. In some embodiments of the present application, the division of the modules is schematic, and is only logical function division, and there may be another division manner in actual implementation.

[0188] Some embodiments of the present application further provide a schematic diagram of a hardware structure of an air conditioner, as shown in FIG. 20, the air conditioner 3000 includes a processor 3001, and in some embodiments, further includes a memory 3002 and a communication interface 3003 connected to the processor 3001. The processor 3001, the memory 3002, and the communication interface 3003 are connected by a bus 3004.

[0189] The processor 3001 may be a central processing unit (CPU), a general-purpose processor, a network processor (NP), a digital signal processor (DSP), a microprocessor, a microcontroller, a programmable logic device (PLD), or any combination thereof.

[0190] The memory 3002 may be a read-only memory (ROM) or other types of static storage devices that may store static information and instructions, a random access memory (RAM) or other types of dynamic storage devices that may store information and instructions, an electrically erasable programmable read-only memory (EEPROM), a compact disc read-only memory (CD-ROM), or other optical storages.

[0191] The communication interface 3003 may be configured for being in communication with other devices or communication networks.

[0192] The bus 3004 may be a peripheral component interconnect (PCI) bus, an extended industry standard architecture (EISA) bus, or the like. The bus 3004 may be divided into an address bus, a data bus, a control bus, or the like. For ease of illustration, the bus is represented only by one thick line in FIG. 20, but which does not indicate only one bus or one type of buses.

[0193] The one or more memories 3002 are configured for storing computer program codes including computer instructions, and when the one or more processors 3002 execute the computer instructions, the controller executes the method for controlling an air conditioning system and the method for determining the ideal energy efficiency ratio of a water chilling unit provided in the above possible implementations. Reference may be made to the foregoing for specific implementation, which is not explained herein.

[0194] It will be understood by those skilled in the art that the scope of the disclosure of the present application is not limited to the particular embodiments described above, and that modifications and substitutions of certain elements of the embodiments may be made without departing from the spirit of the application. The scope of the present application is limited by the appended claims.

Claims

1. An air conditioning system, comprising:

a water chilling unit;
a refrigerant circulation loop configured for circulating a refrigerant in a loop comprising a compressor, a condenser, and an evaporator;
a first temperature sensor configured for detecting a condensation temperature of the condenser;
a second temperature sensor configured for detecting an evaporation temperature of the evaporator; and
a controller configured for:

using the first temperature sensor to obtain a first condensation temperature in an n-th detection period, and using the second temperature sensor to obtain a first evaporation temperature in the n-th detection period, n being an integer greater than 1;
obtaining operating parameters of the water chilling unit, and based on the operating parameters, determining a second condensation temperature of the condenser in the n-th detection period and a second evaporation temperature of the evaporator in the n-th detection period;
determining a first energy efficiency ratio in the n-th detection period according to the first condensation temperature and the first evaporation temperature;
determining a second energy efficiency ratio in the n-th detection period according to the second condensation temperature and the second evaporation temperature; and
determining an ideal energy efficiency ratio in the n-th detection period according to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period.

2. The air conditioning system according to claim 1, wherein the controller is further configured for:

determining the ideal energy efficiency ratio in the n-th period according to the first energy efficiency ratio in the n-th detection period, the second energy efficiency ratio in the n-th detection period, a first value range, and a second value range;
wherein the first value range is determined according to an average value and a standard deviation of first energy efficiency ratios in n detection periods, and the second value range is determined according to an average value and a standard deviation of second energy efficiency ratios in the n detection periods.

3. The air conditioning system according to claim 2, wherein the controller is further configured for:

when the first energy efficiency ratio in the n-th detection period is not within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, taking an average value of the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period as the ideal energy efficiency ratio in the n-th detection period; or
when the first energy efficiency ratio in the n-th detection period is within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, taking the first energy efficiency ratio in the n-th period as the ideal energy efficiency ratio in the n-th period; or
when the second energy efficiency ratio in the n-th detection period is within the second value range, taking the second energy efficiency ratio in the n-th detection period as the ideal energy efficiency ratio in the n-th period.

4. The air conditioning system according to any one of claims 1 to 3, wherein the water chilling unit comprises chilled water and cooling water;

the operating parameters of the water chilling unit comprise: a temperature difference between a supply water temperature and return water temperature of the chilled water in each detection period, a temperature difference between a supply water temperature and return water temperature of the cooling water in each detection period, a heat exchange temperature difference of the evaporator in each detection period, a heat exchange temperature difference of the condenser in each detection period, a supply water temperature of the chilled water in each detection period, a return water temperature of the cooling water in each detection period, and a cooling load ratio of the water chilling unit in each detection period;
the controller is further configured for:

determining the second condensation temperature of the condenser in the n-th detection period according to the water temperature difference between the supply water temperature and return water temperature of the cooling water in the n-th detection period, the heat exchange temperature difference of the condenser in the n-th detection period, the return water temperature of the cooling water in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period; and
determining the second evaporation temperature of the evaporator in the n-th detection period according to the temperature difference between the supply water temperature and return water temperature of the chilled water in the n-th detection period, the heat exchange temperature difference of the evaporator in the n-th detection period, the supply water temperature of the chilled water in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period.

5. The air conditioning system according to claim 4, wherein the operating parameters of the water chilling unit further comprise electric power of the water chilling unit in each detection period;
the controller is further configured for:
after determining the ideal energy efficiency ratio in the n-th detection period, determining a cooling load of the water chilling unit in the n-th detection period according to the electric power of the water chilling unit in the n-th detection period, the cooling load ratio of the water chilling unit in the n-th detection period, and the ideal energy efficiency ratio in the n-th detection period.

6. An air conditioning system, comprising:

an evaporator;
a condenser; and
a controller electrically connected to the evaporator and the condenser, the controller being configured for:

obtaining an evaporation temperature of the air conditioning system, a condensation temperature of the air conditioning system, a first energy efficiency ratio of the air conditioning system, and a load ratio of the air conditioning system according to operating data of the evaporator and the condenser in a preset duration;
obtaining a second energy efficiency ratio of the air conditioning system and a first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system according to the evaporation temperature of the air conditioning system, the condensation temperature of the air conditioning system, the first energy efficiency ratio of the air conditioning system, and the load ratio of the air conditioning system;
obtaining a second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system by using a back propagation neural network model; and
obtaining a third corresponding relationship between a target energy efficiency ratio of the air conditioning system and the load ratio of the air conditioning system by using the first corresponding relationship and the second corresponding relationship based on a mean clustering algorithm.

7. The air conditioning system according to claim 6, wherein the operating data of the evaporator and the condenser in the preset duration comprises a supply chilled water temperature, a return chilled water temperature, a chilled water flow rate, and an evaporator evaporation temperature of the evaporator, a supply cooling water temperature, a return cooling water temperature, a cooling water flow rate, and a condenser condensation temperature of the condenser, and a water chilling unit load ratio and water chilling unit power of the air conditioning system;
wherein the operating data corresponding to each time point in the preset duration forms a data set.

8. The air conditioning system according to claim 7, wherein the controller is further configured for:

obtaining a water chilling unit direct load according to a specific heat capacity of water and the chilled water flow

rate, the return chilled water temperature, and the supply chilled water temperature in a target data set in the operating data;
obtaining a water chilling unit cooling amount according to the specific heat capacity of water and the cooling water flow rate, the return cooling water temperature, and the supply cooling water temperature in the target data set in the operating data;
obtaining an evaporator logarithmic mean temperature difference corresponding to the target data set according to a temperature difference between the supply chilled water temperature and the evaporator evaporation temperature in the target data set and a temperature difference between the return chilled water temperature and the evaporator evaporation temperature in the target data set;
obtaining an evaporator heat transfer coefficient corresponding to the target data set according to the water chilling unit direct load and the evaporator logarithmic mean temperature difference;
performing fitting according to the evaporator heat transfer coefficients corresponding to different data sets to obtain an evaporator target heat transfer coefficient; and
obtaining the evaporation temperature of the air conditioning system according to a density of water, the specific heat capacity of water, the evaporator target heat transfer coefficient, the water chilling unit direct load, the chilled water flow rate, and the supply chilled water temperature.

9. The air conditioning system according to claim 7, wherein the controller is further configured for:

obtaining a water chilling unit direct load according to a specific heat capacity of water and the chilled water flow rate, the return chilled water temperature, and the supply chilled water temperature in a target data set in the operating data;
obtaining a water chilling unit cooling amount according to the specific heat capacity of water and the cooling water flow rate, the return cooling water temperature, and the supply cooling water temperature in the target data set in the operating data;
obtaining a condenser logarithmic mean temperature difference corresponding to the target data set according to a temperature difference between the supply cooling water temperature and the condenser condensation temperature in the target data set and a temperature difference between the return cooling water temperature and the condenser condensation temperature in the target data set;
obtaining a condenser heat transfer coefficient corresponding to the target data set according to the water chilling unit direct load and the condenser logarithmic mean temperature difference;
performing fitting according to the condenser heat transfer coefficients corresponding to different data sets to obtain a condenser target heat transfer coefficient; and
obtaining the condensation temperature of the air conditioning system according to the density of water, the specific heat capacity of water, the condenser target heat transfer coefficient, the water chilling unit direct load, the cooling water flow rate, and the return cooling water temperature.

10. The air conditioning system according to claim 8 or 9, wherein the controller is further configured for:

obtaining a load unbalance ratio according to the water chilling unit direct load, the water chilling unit cooling amount, and the water chilling unit power in the target data set in the operating data; and
deleting data in the target data set from the operating data under a condition that the load unbalance ratio is greater than or equal to a preset load unbalance ratio.

11. The air conditioning system according to claim 8 or 9, wherein the controller is further configured for:

obtaining the first energy efficiency ratio of the air conditioning system according to the water chilling unit direct load and the water chilling unit power in the target data set in the operating data; and
deleting the data in the target data set from the operating data under a condition that the first energy efficiency ratio is outside a preset interval.

12. The air conditioning system according to claim 6 or 7, wherein the controller is further configured for:

obtaining the second energy efficiency ratio of the air conditioning system according to the evaporation temperature, the condensation temperature, the first energy efficiency ratio, and the load ratio;
with the second energy efficiency ratio as an abscissa and the load ratio corresponding to the second energy efficiency ratio as an ordinate, generating a scatter diagram composed of a plurality of data points, each data point corresponding to one second energy efficiency ratio and one load ratio; and

fitting the data points on the scatter diagram to obtain the first corresponding relationship represented by a curve.

13. The air conditioning system according to claim 6 or 7, wherein the controller is further configured for: inputting the water chilling unit load ratio and a temperature difference between the evaporation temperature and the condensation temperature of the air conditioning system in the operating data into the back propagation neural network model to obtain the second energy efficiency ratio and the second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system.

14. The air conditioning system according to claim 6 or 7, wherein the controller is further configured for:

obtaining data similarity between a current data set and the target data set in the operating data based on the water chilling unit load ratio and the temperature difference between the evaporation temperature and the condensation temperature of the air conditioning system; the current data set comprising operating data obtained after the preset duration;
establishing the third corresponding relationship according to the first corresponding relationship under a condition that the data similarity is smaller than or equal to preset similarity; and
establishing the third corresponding relationship according to the second corresponding relationship under a condition that the data similarity is greater than the preset similarity.

15. A method for determining the energy efficiency ratio of an air conditioning system, the method being applied to a water chilling unit in the air conditioning system, and the method comprising:

using a first temperature sensor to obtain a first condensation temperature of a condenser in an n-th detection period, and using a second temperature sensor to obtain a first evaporation temperature of an evaporator during the n-th detection period, n being an integer greater than 1;
obtaining operating parameters of the water chilling unit, and based on the operating parameters, determining a second condensation temperature of the condenser in the n-th detection period and a second evaporation temperature of the evaporator in the n-th detection period;
determining a first energy efficiency ratio in the n-th detection period according to the first condensation temperature and the first evaporation temperature;
determining a second energy efficiency ratio in the n-th detection period according to the second condensation temperature and the second evaporation temperature; and
determining an ideal energy efficiency ratio in the n-th detection period according to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period.

16. A method for controlling an air conditioning system, comprising:

obtaining an evaporation temperature of the air conditioning system, a condensation temperature of the air conditioning system, a first energy efficiency ratio of the air conditioning system, and a load ratio of the air conditioning system according to operating data of an evaporator and a condenser in a preset duration;
obtaining a second energy efficiency ratio of the air conditioning system and a first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system according to the evaporation temperature of the air conditioning system, the condensation temperature of the air conditioning system, the first energy efficiency ratio of the air conditioning system, and the load ratio of the air conditioning system;
obtaining a second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system by using a back propagation neural network model; and
obtaining a third corresponding relationship between a target energy efficiency ratio of the air conditioning system and the load ratio of the air conditioning system by using the first corresponding relationship and the second corresponding relationship based on a mean clustering algorithm.

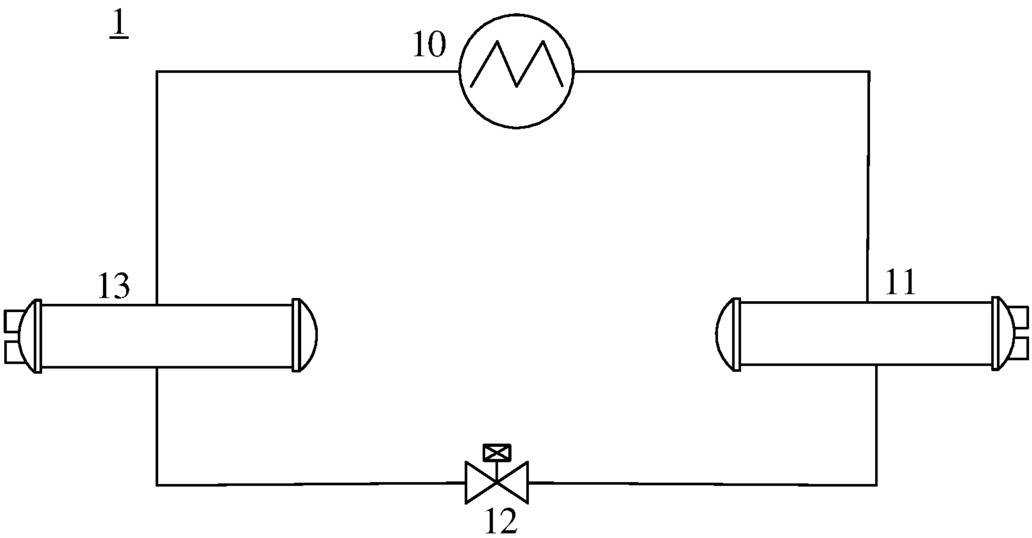

FIG. 1

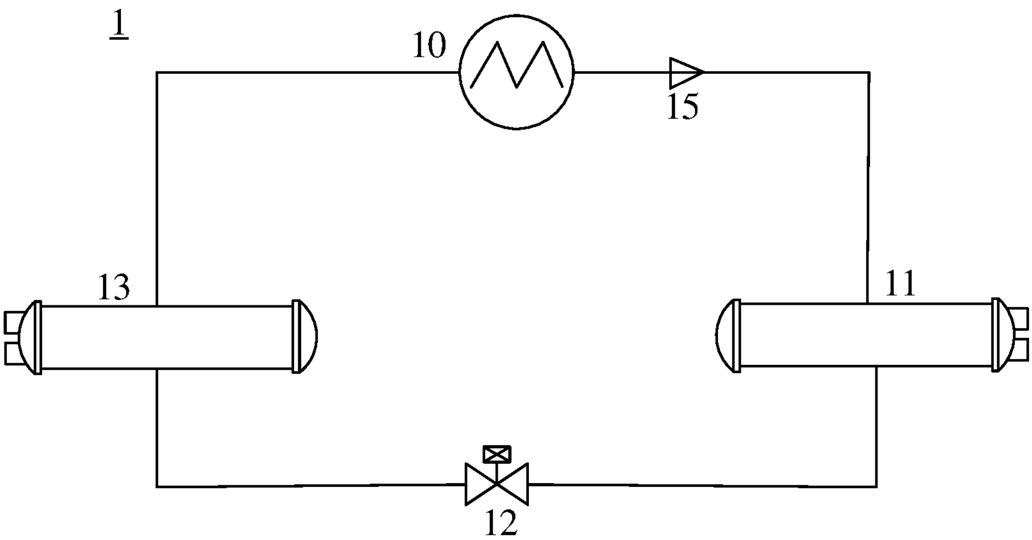

FIG. 2

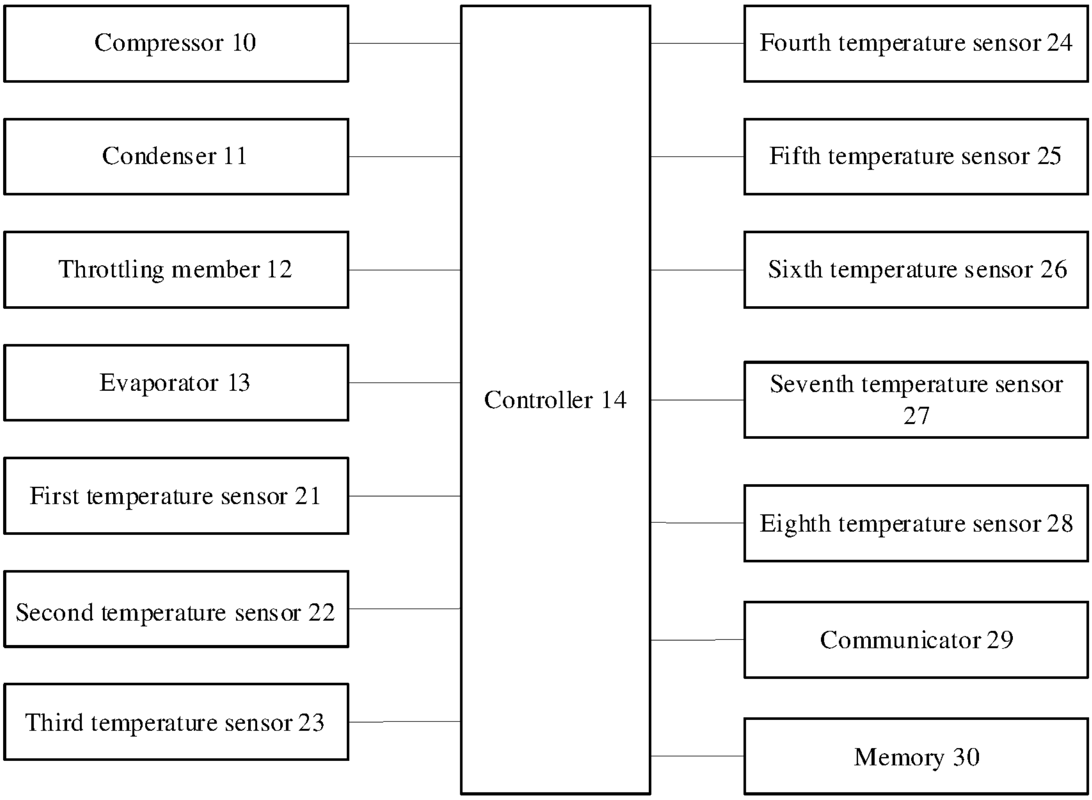
Compressor 10
Condenser 11
Throttling member 12
Evaporator 13
First temperature sensor 21
Second temperature sensor 22
Third temperature sensor 23
Controller 14
Fourth temperature sensor 24
Fifth temperature sensor 25
Sixth temperature sensor 26
Seventh temperature sensor 27
Eighth temperature sensor 28
Communicator 29
Memory 30

FIG. 3

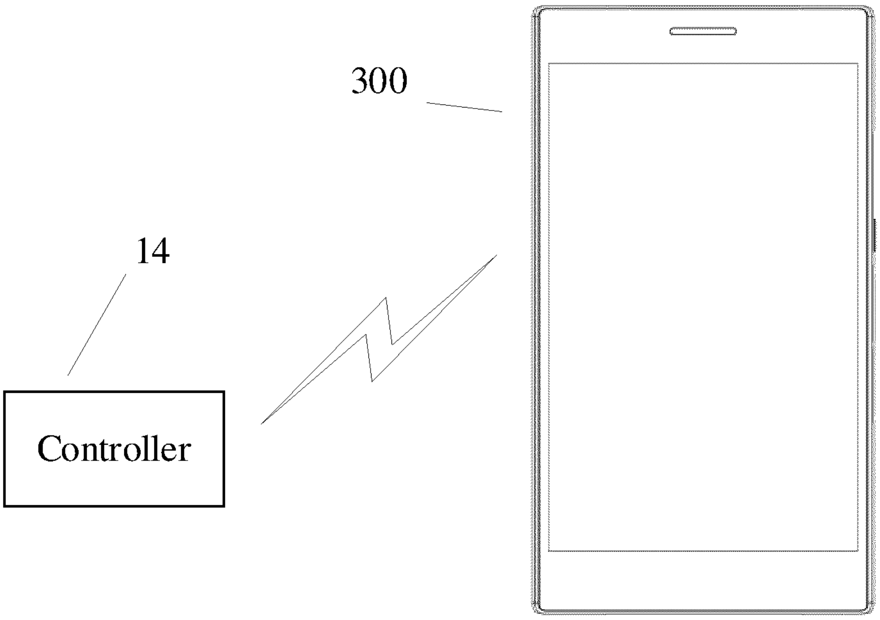
300
14
Controller

FIG. 4

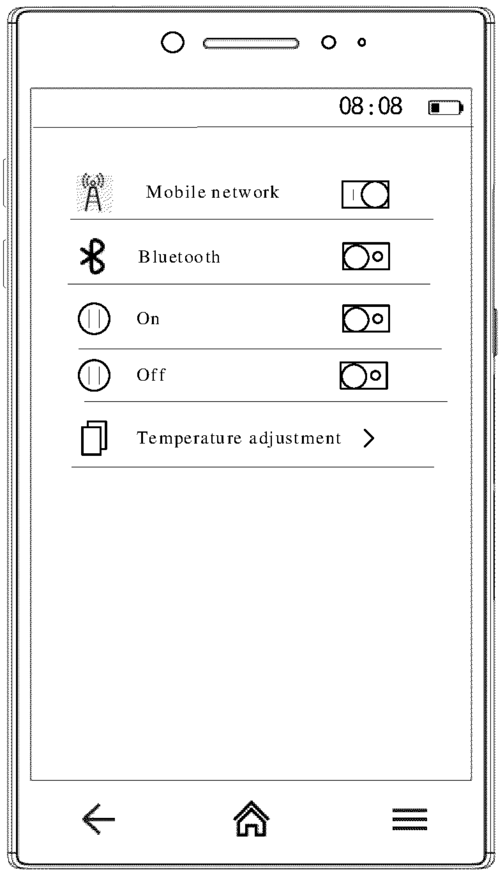
08:08
Mobile network
Bluetooth
On
Off
Temperature adjustment

FIG. 5

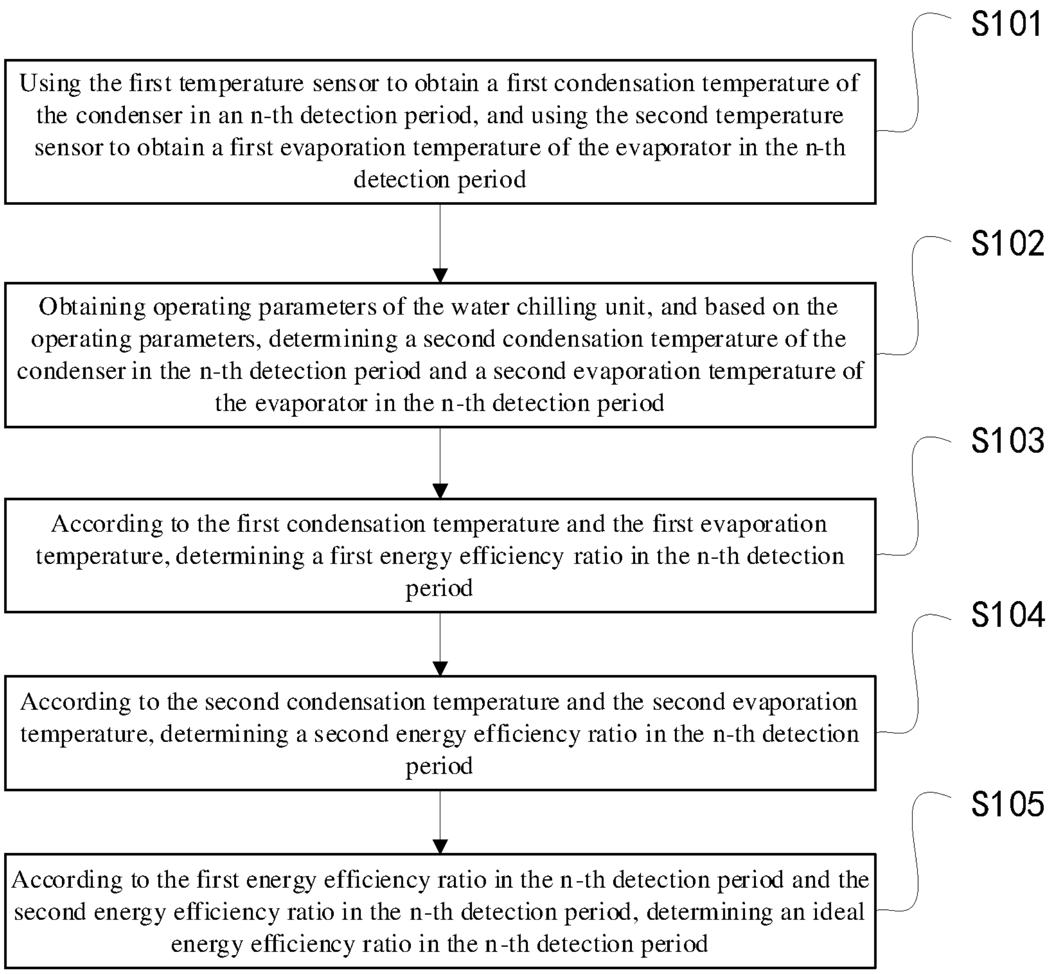
S101
Using the first temperature sensor to obtain a first condensation temperature of the condenser in an n-th detection period, and using the second temperature sensor to obtain a first evaporation temperature of the evaporator in the n-th detection period
S102
Obtaining operating parameters of the water chilling unit, and based on the operating parameters, determining a second condensation temperature of the condenser in the n-th detection period and a second evaporation temperature of the evaporator in the n-th detection period
S103
According to the first condensation temperature and the first evaporation temperature, determining a first energy efficiency ratio in the n-th detection period
S104
According to the second condensation temperature and the second evaporation temperature, determining a second energy efficiency ratio in the n-th detection period
S105
According to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period, determining an ideal energy efficiency ratio in the n-th detection period

FIG. 6

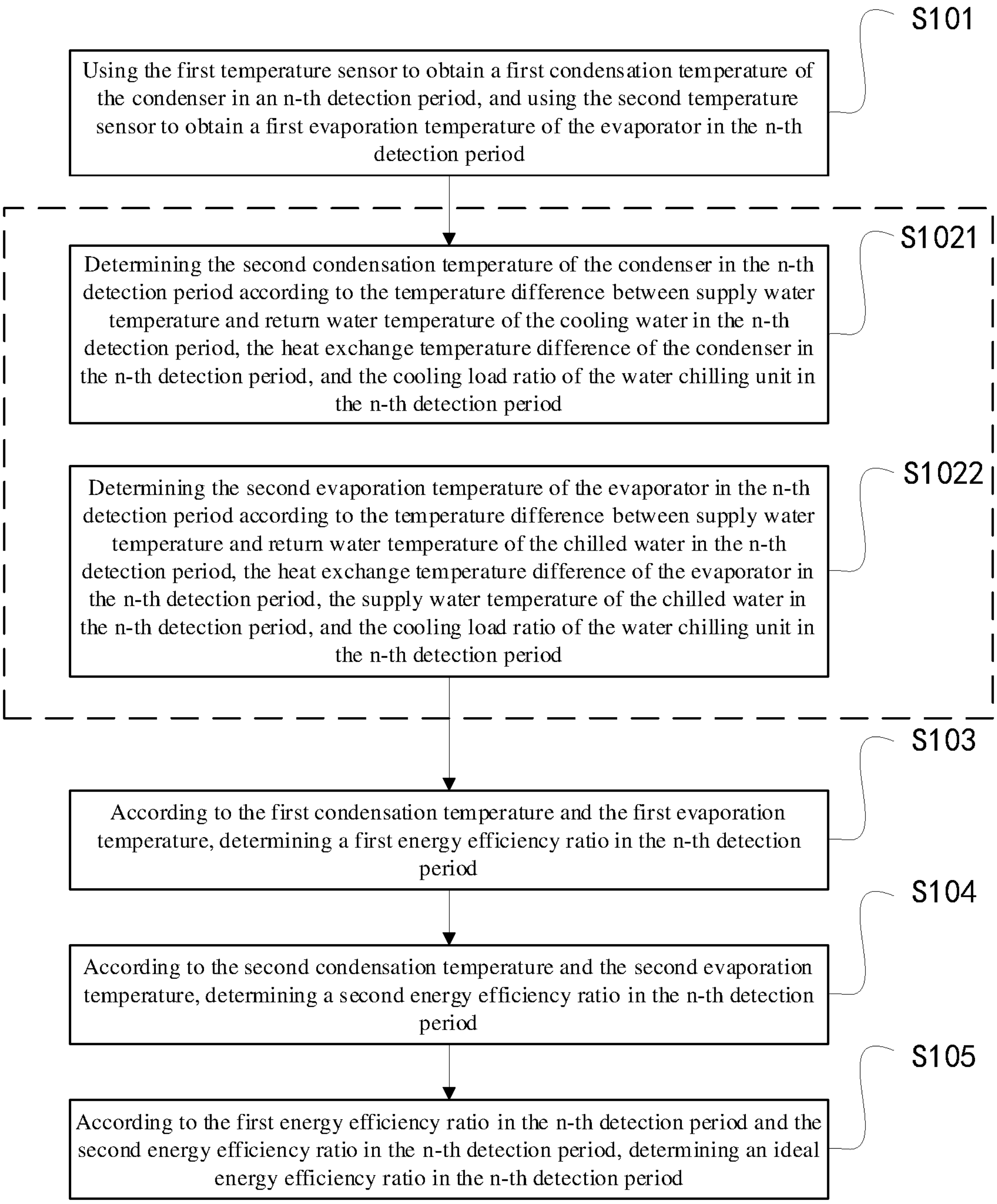
S101
Using the first temperature sensor to obtain a first condensation temperature of the condenser in an n-th detection period, and using the second temperature sensor to obtain a first evaporation temperature of the evaporator in the n-th detection period
S1021
Determining the second condensation temperature of the condenser in the n-th detection period according to the temperature difference between supply water temperature and return water temperature of the cooling water in the n-th detection period, the heat exchange temperature difference of the condenser in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period
S1022
Determining the second evaporation temperature of the evaporator in the n-th detection period according to the temperature difference between supply water temperature and return water temperature of the chilled water in the n-th detection period, the heat exchange temperature difference of the evaporator in the n-th detection period, the supply water temperature of the chilled water in the n-th detection period, and the cooling load ratio of the water chilling unit in the n-th detection period
S103
According to the first condensation temperature and the first evaporation temperature, determining a first energy efficiency ratio in the n-th detection period
S104
According to the second condensation temperature and the second evaporation temperature, determining a second energy efficiency ratio in the n-th detection period
S105
According to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period, determining an ideal energy efficiency ratio in the n-th detection period

FIG. 7

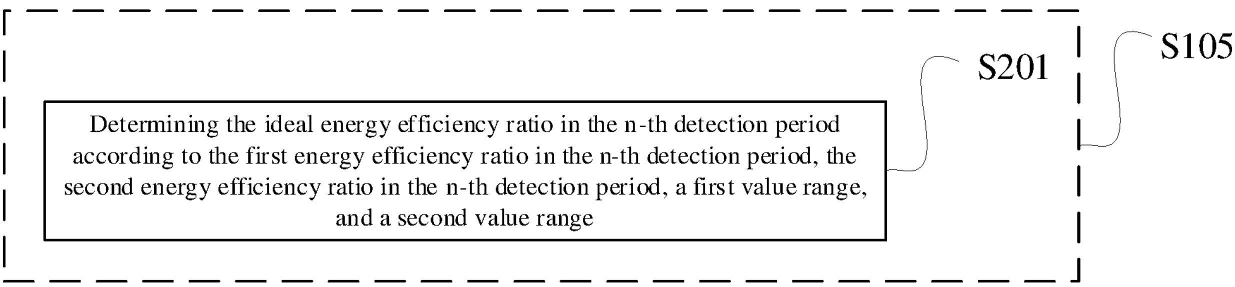
S105
S201
Determining the ideal energy efficiency ratio in the n-th detection period according to the first energy efficiency ratio in the n-th detection period, the second energy efficiency ratio in the n-th detection period, a first value range, and a second value range

FIG. 8

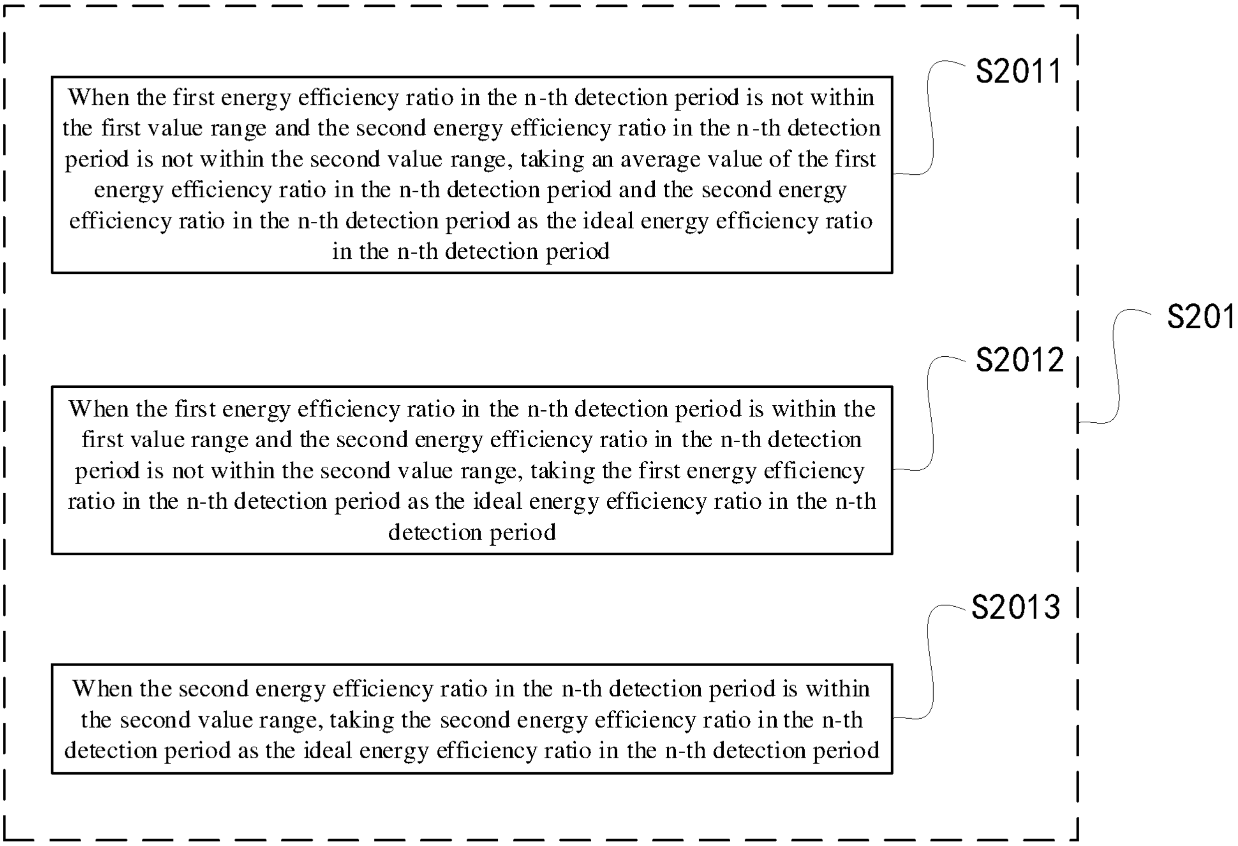
S2011
When the first energy efficiency ratio in the n-th detection period is not within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, taking an average value of the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period as the ideal energy efficiency ratio in the n-th detection period
S201
S2012
When the first energy efficiency ratio in the n-th detection period is within the first value range and the second energy efficiency ratio in the n-th detection period is not within the second value range, taking the first energy efficiency ratio in the n-th detection period as the ideal energy efficiency ratio in the n-th detection period
S2013
When the second energy efficiency ratio in the n-th detection period is within the second value range, taking the second energy efficiency ratio in the n-th detection period as the ideal energy efficiency ratio in the n-th detection period

FIG. 9

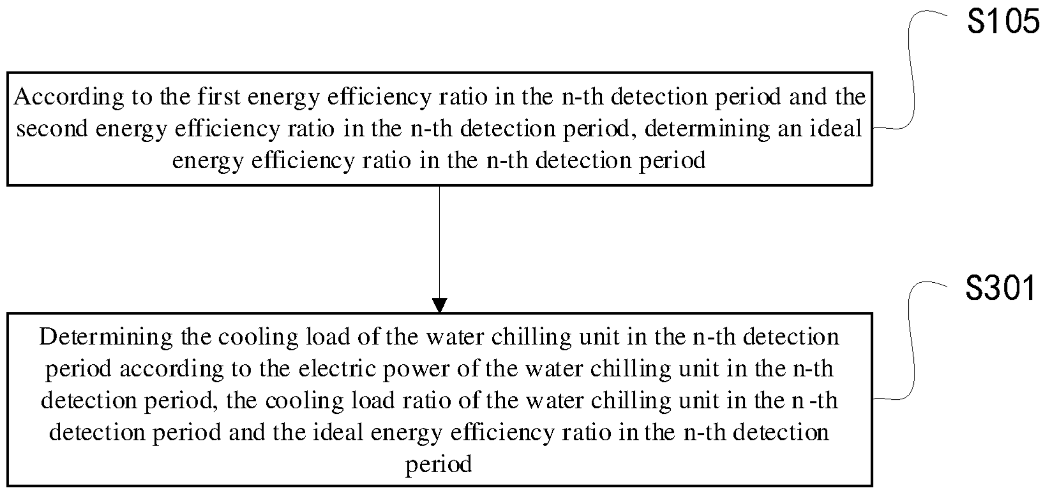
S105
According to the first energy efficiency ratio in the n-th detection period and the second energy efficiency ratio in the n-th detection period, determining an ideal energy efficiency ratio in the n-th detection period
S301
Determining the cooling load of the water chilling unit in the n-th detection period according to the electric power of the water chilling unit in the n-th detection period, the cooling load ratio of the water chilling unit in the n-th detection period and the ideal energy efficiency ratio in the n-th detection period

FIG. 10

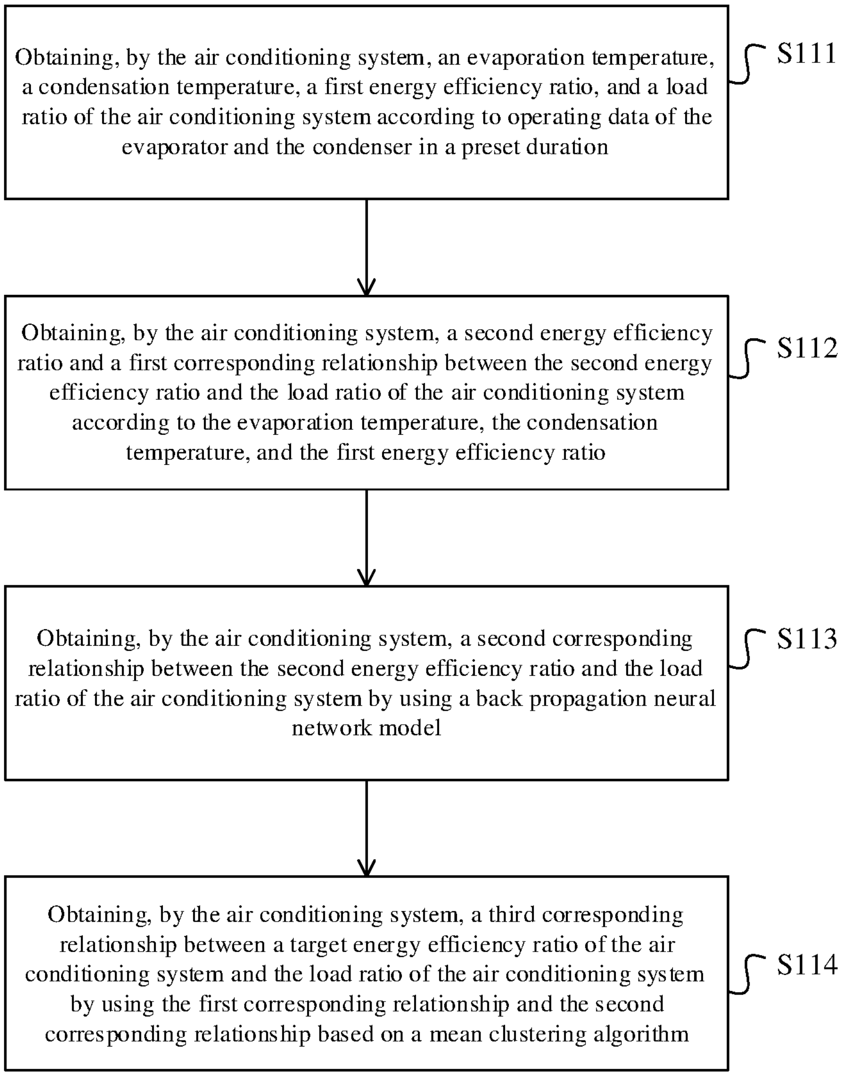
Obtaining, by the air conditioning system, an evaporation temperature, a condensation temperature, a first energy efficiency ratio, and a load ratio of the air conditioning system according to operating data of the evaporator and the condenser in a preset duration
S111
Obtaining, by the air conditioning system, a second energy efficiency ratio and a first corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system according to the evaporation temperature, the condensation temperature, and the first energy efficiency ratio
S112
Obtaining, by the air conditioning system, a second corresponding relationship between the second energy efficiency ratio and the load ratio of the air conditioning system by using a back propagation neural network model
S113
Obtaining, by the air conditioning system, a third corresponding relationship between a target energy efficiency ratio of the air conditioning system and the load ratio of the air conditioning system by using the first corresponding relationship and the second corresponding relationship based on a mean clustering algorithm
S114

FIG. 11

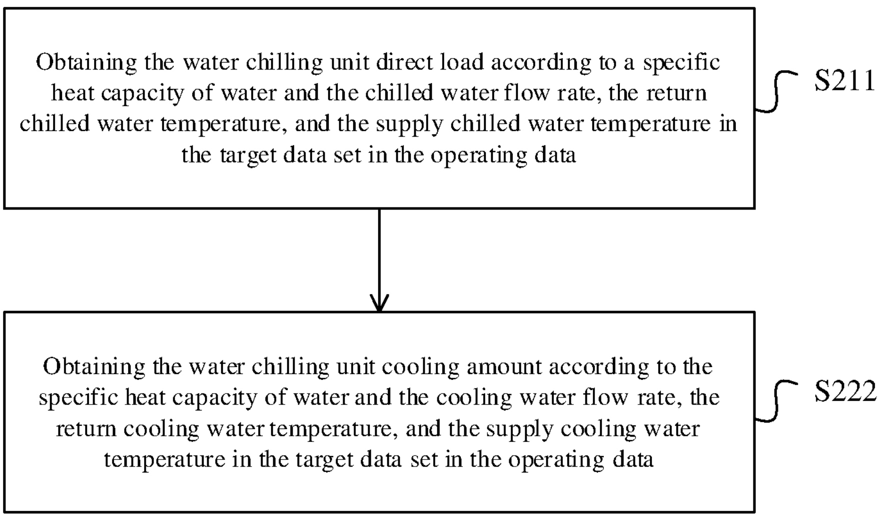
Obtaining the water chilling unit direct load according to a specific heat capacity of water and the chilled water flow rate, the return chilled water temperature, and the supply chilled water temperature in the target data set in the operating data
S211
Obtaining the water chilling unit cooling amount according to the specific heat capacity of water and the cooling water flow rate, the return cooling water temperature, and the supply cooling water temperature in the target data set in the operating data
S222

FIG. 12

Obtaining the first energy efficiency ratio of the air conditioning system according to the water chilling unit direct load and the water chilling unit power in the target data set in the operating data

S311

Deleting the data in the target data set from the operating data under the condition that the first energy efficiency ratio is outside a preset interval

S312

FIG. 13

Obtaining an evaporator logarithmic mean temperature difference corresponding to the target data set according to a temperature difference between the supply chilled water temperature and the evaporator evaporation temperature in the target data set and a temperature difference between the return chilled water temperature and the evaporator evaporation temperature in the target data set

S411

Obtaining an evaporator heat transfer coefficient corresponding to the target data set according to the water chilling unit direct load and the evaporator logarithmic mean temperature difference

S412

Performing fitting according to the evaporator heat transfer coefficients corresponding to different data sets to obtain an evaporator target heat transfer coefficient

S413

Obtaining the evaporation temperature of the air conditioning system according to a density of water, the specific heat capacity of water, the evaporator target heat transfer coefficient, the water chilling unit direct load, the chilled water flow rate, and the supply chilled water temperature

S414

FIG. 14

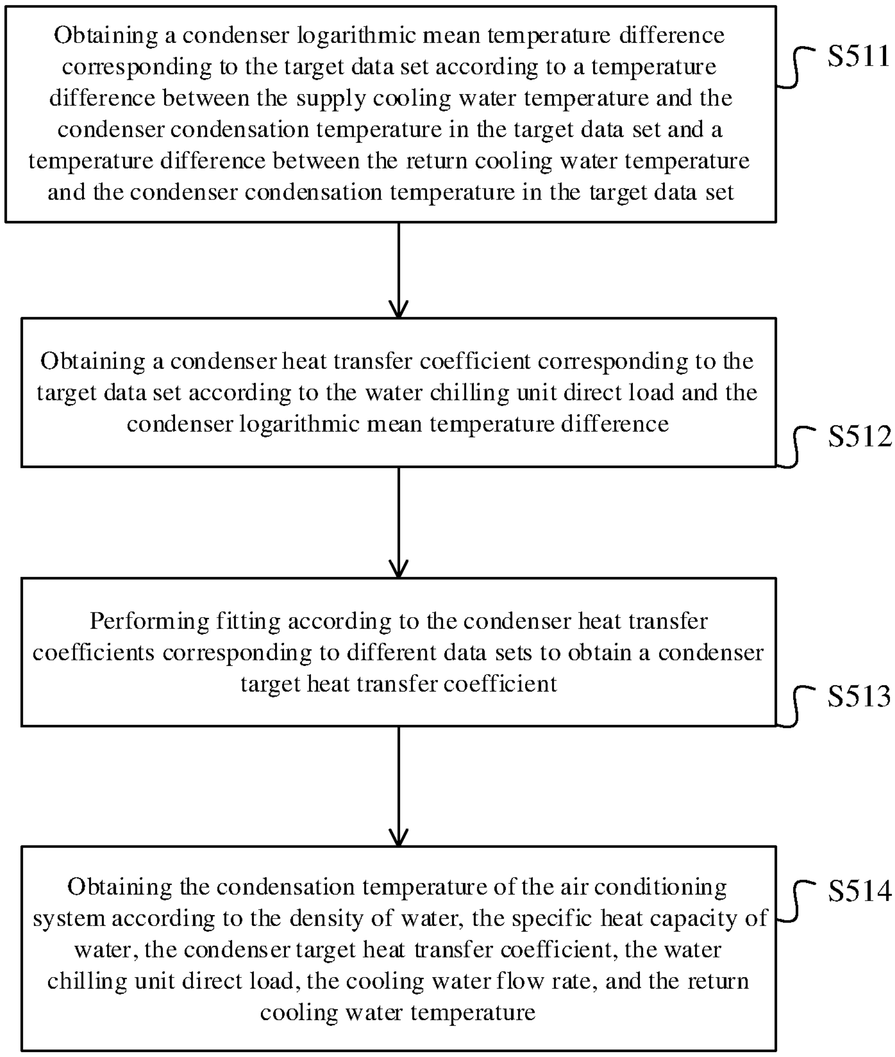
Obtaining a condenser logarithmic mean temperature difference corresponding to the target data set according to a temperature difference between the supply cooling water temperature and the condenser condensation temperature in the target data set and a temperature difference between the return cooling water temperature and the condenser condensation temperature in the target data set
S511
Obtaining a condenser heat transfer coefficient corresponding to the target data set according to the water chilling unit direct load and the condenser logarithmic mean temperature difference
S512
Performing fitting according to the condenser heat transfer coefficients corresponding to different data sets to obtain a condenser target heat transfer coefficient
S513
Obtaining the condensation temperature of the air conditioning system according to the density of water, the specific heat capacity of water, the condenser target heat transfer coefficient, the water chilling unit direct load, the cooling water flow rate, and the return cooling water temperature
S514

FIG. 15

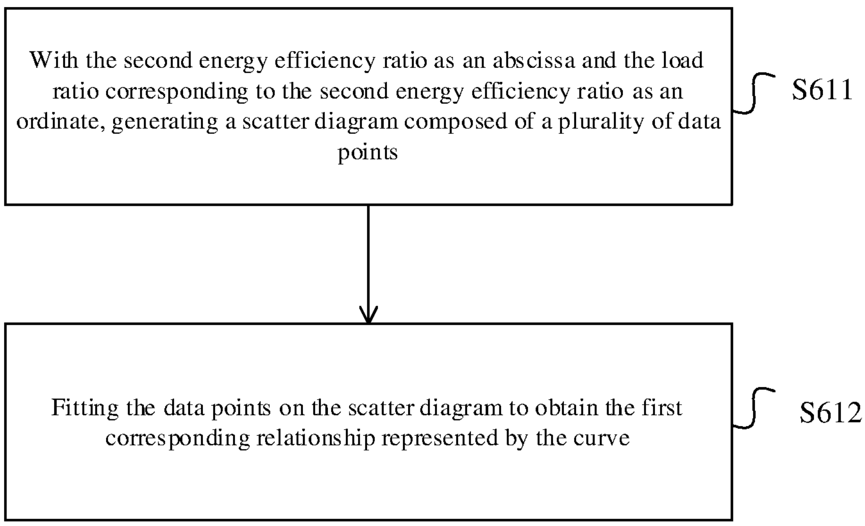
With the second energy efficiency ratio as an abscissa and the load ratio corresponding to the second energy efficiency ratio as an ordinate, generating a scatter diagram composed of a plurality of data points
S611
Fitting the data points on the scatter diagram to obtain the first corresponding relationship represented by the curve
S612

FIG. 16

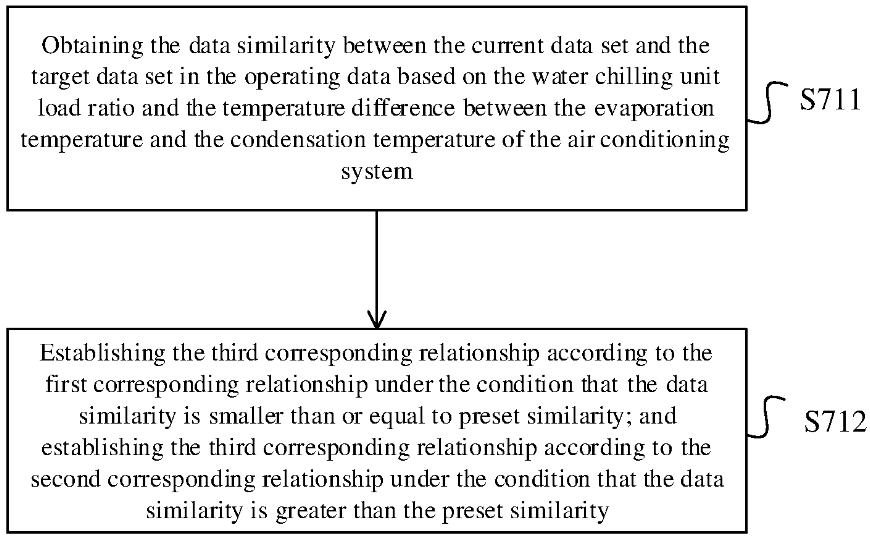
Obtaining the data similarity between the current data set and the target data set in the operating data based on the water chilling unit load ratio and the temperature difference between the evaporation temperature and the condensation temperature of the air conditioning system
S711
Establishing the third corresponding relationship according to the first corresponding relationship under the condition that the data similarity is smaller than or equal to preset similarity; and establishing the third corresponding relationship according to the second corresponding relationship under the condition that the data similarity is greater than the preset similarity
S712

FIG. 17

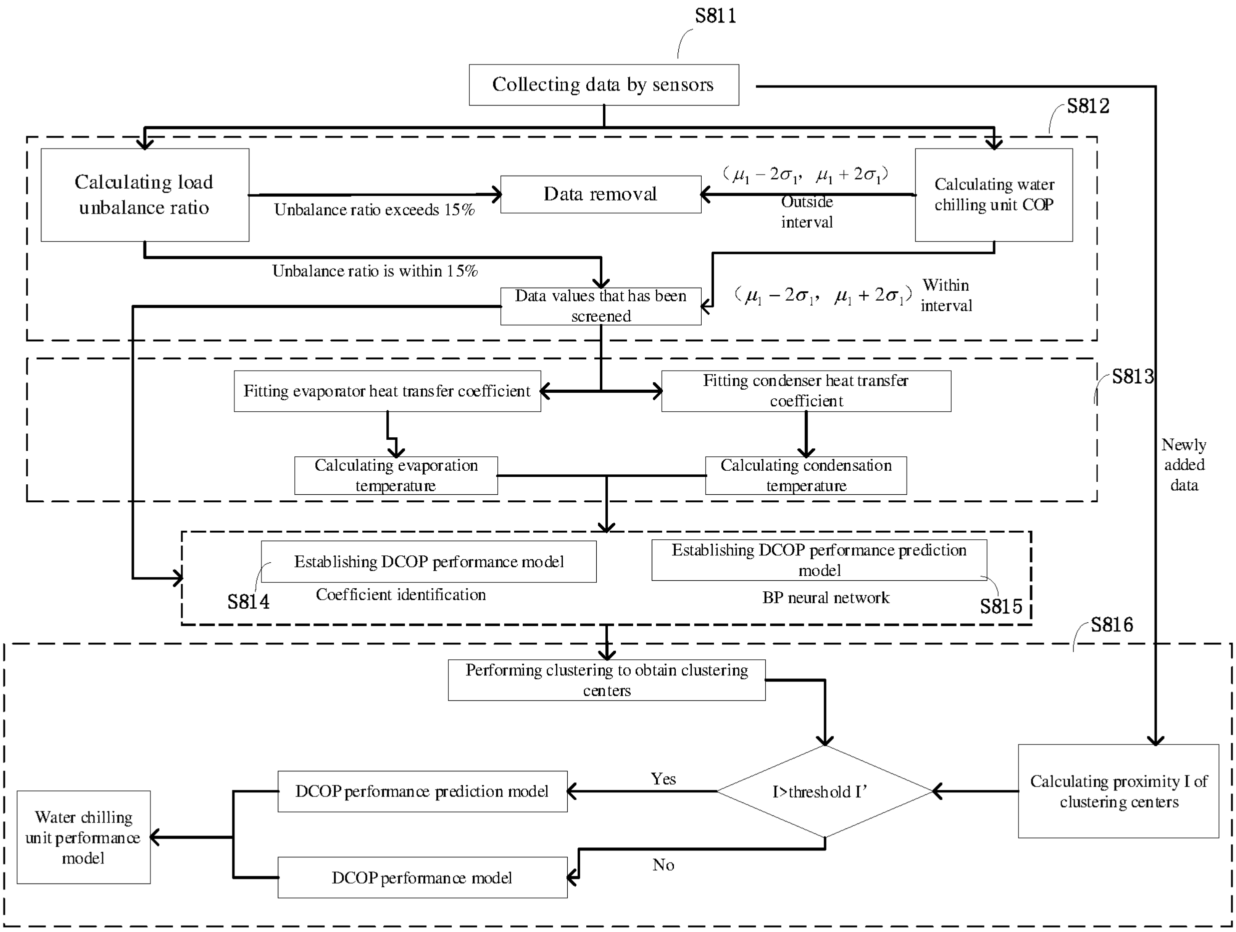
S811
Collecting data by sensors
S812
Calculating load unbalance ratio
Unbalance ratio exceeds 15%
Data removal
$(\mu_1 - 2\sigma_1, \mu_1 + 2\sigma_1)$
Outside interval
Calculating water chilling unit COP
Unbalance ratio is within 15%
Data values that has been screened
$(\mu_1 - 2\sigma_1, \mu_1 + 2\sigma_1)$
Within interval
S813
Fitting evaporator heat transfer coefficient
Fitting condenser heat transfer coefficient
Calculating evaporation temperature
Calculating condensation temperature
Newly added data
Establishing DCOP performance model
Establishing DCOP performance prediction model
S814
Coefficient identification
BP neural network
S815
S816
Performing clustering to obtain clustering centers
I>threshold I'
Yes
No
DCOP performance prediction model
DCOP performance model
Calculating proximity I of clustering centers
Water chilling unit performance model

FIG. 18

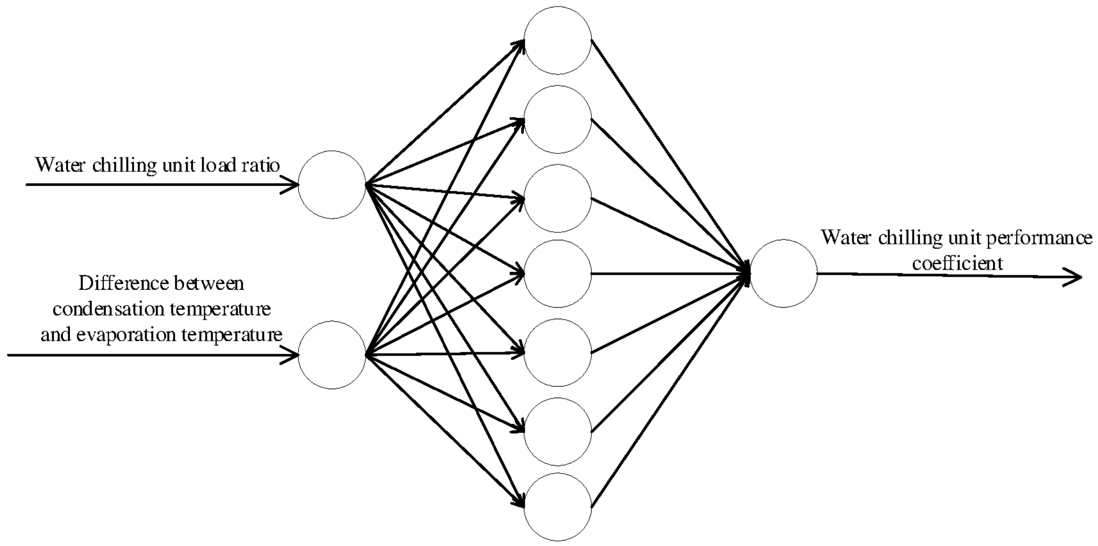
Water chilling unit load ratio
Difference between condensation temperature and evaporation temperature
Water chilling unit performance coefficient

FIG. 19

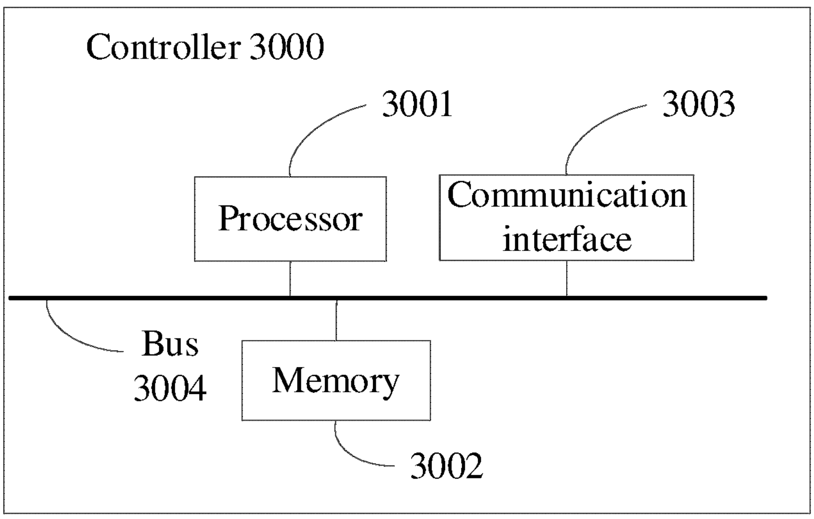
Controller 3000
3001
3003
Processor
Communication interface
Bus 3004
Memory
3002

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/107322

A. CLASSIFICATION OF SUBJECT MATTER

F24F11/61(2018.01)i; F24F11/56(2018.01)i; F24F11/83(2018.01)i; F24F140/20(2018.01)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)

IPC: F24F

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)

CNTXT, ENTXT, VEN, CNKI: 冷凝温度, 蒸发温度, 能效比, 运行数据, 负荷率, 关系, condensing temperature, evaporating temperature, EER, energy efficiency ratio, COP, operating data, load rate, relationship

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 115264973 A (QINGDAO HISENSE HITACHI AIR CONDITIONING SYSTEM CO., LTD.) 01 November 2022 (2022-11-01) description, paragraphs 46-173, figures 1-11	1-5, 15
PX	CN 115264771 A (QINGDAO HISENSE HITACHI AIR CONDITIONING SYSTEM CO., LTD.) 01 November 2022 (2022-11-01) description, paragraphs 49-222, figures 1-16	6-14, 16
A	CN 104121700 A (GREE ELECTRIC APPLIANCES, INC. OF ZHUHAI) 29 October 2014 (2014-10-29) description, paragraphs 23-67, figures 1-2	1-5, 15
A	CN 111623570 A (CHANGZHOU INSTITUTE OF TECHNOLOGY) 04 September 2020 (2020-09-04) entire document	1-5, 15
A	CN 109595763 A (GREE ELECTRIC APPLIANCES, INC. OF ZHUHAI) 09 April 2019 (2019-04-09) entire document	1-5, 15

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
19 September 2023	**20 September 2023**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	 Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/107322

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2021042847 A1 (GREE ELECTRIC APPLIANCES, INC. OF ZHUHAI) 11 March 2021 (2021-03-11) entire document	1-5, 15
A	CN 111914404 A (SOUTHEAST UNIVERSITY) 10 November 2020 (2020-11-10) description, paragraphs 77-237, figures 1-5	6-14, 16
A	CN 109063255 A (GUANGZHOU CANLEAD ENERGY TECHNOLOGY CO., LTD.) 21 December 2018 (2018-12-21) entire document	6-14, 16
A	CN 112856722 A (DING, Yi; XU, Shiyu) 28 May 2021 (2021-05-28) entire document	6-14, 16
A	CN 113326651 A (BEIJING UNIVERSITY OF CIVIL ENGINEERING AND ARCHITECTURE et al.) 31 August 2021 (2021-08-31) entire document	6-14, 16
A	EP 3882524 A1 (MITSUBISHI ELECTRIC CORP. et al.) 22 September 2021 (2021-09-22) entire document	6-14, 16

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/107322

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1 and 15 and claims 6 and 16 have the common technical features "evaporator", "condenser", "controller" and "energy efficiency ratio"; however, these technical features are well known in the art. Therefore, claims 1 and 15 and claims 6 and 16 do not have a special technical feature, and thus lack unity of invention therebetween.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☑ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/107322

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 115264973 A	01 November 2022	None	
CN 115264771 A	01 November 2022	None	
CN 104121700 A	29 October 2014	WO 2014173269 A1	30 October 2014
CN 111623570 A	04 September 2020	None	
CN 109595763 A	09 April 2019	WO 2020125184 A1	25 June 2020
WO 2021042847 A1	11 March 2021	None	
CN 111914404 A	10 November 2020	None	
CN 109063255 A	21 December 2018	None	
CN 112856722 A	28 May 2021	None	
CN 113326651 A	31 August 2021	None	
EP 3882524 A1	22 September 2021	US 2023065130 A1	02 March 2023
		JPWO 2021187423 A1	23 September 2021
		WO 2021187423 A1	23 September 2021

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- CN 202210822346 **[0001]**
- CN 202210867618 **[0001]**