

SERVER RACK COOLING SYSTEM OF DATA CENTER

Technical Field

The present invention relates to a server rack cooling system of a data center, and more specifically, to a server rack cooling system of a data center that does not require a hot zone space inside a computer room, can implement a zero water system inside the computer room, and can perform a cooling operation for each server rack.

Background Art

In general, data centers are industrial buildings that prioritize maintaining an operating environment of information technology (IT) equipment (servers) in optimal conditions rather than being residential spaces for people.

That is, in order to protect the equipment and provide stable operating conditions, the data centers are focused on environmental adjustment rather than energy conservation. This is because the economic loss caused by errors or failures in IT equipment (servers) is much greater than energy costs, and accordingly, data centers do not consider active energy conservation measures.

However, securing sustainable growth through IT is an important task for companies in line with global trends, and recently, with the expansion of a cloud computing market, computing environment has been highly integrated and a large number of servers are being operated, and accordingly, the rapidly increasing energy consumption of data centers, which consume up to 40 times more energy than general buildings, is becoming a social issue.

Therefore, it is an inevitable task to operate the green Internet data center (green IDC) system that improves an operation method of the known Internet data center to an eco-friendly and energy-saving method.

An air conditioning system of a known green Internet data center is disclosed in Korean Patent Publication No. 10-2011-0129514, "Air conditioning system of Internet data center for Green computing environment", which consists of an air conditioner for cooling and ventilation to maintain the indoor temperature of an Internet data center, an air conditioner control device that controls an operation of the air conditioner, a temperature sensor that detects the indoor and outdoor (ground floor and underground

floor) temperatures and provides the information to the air conditioner control device, a cooling duct for cooling the Internet data center from the air conditioner, a ventilation duct for efficiently discharging the heat generated from racks equipped with servers and network devices to the outside, and a partition equipped with a ventilation hole connected thereto.

However, the conventional air conditioning system of such Internet data centers has a problem in that energy saving methods are not considered at all in introducing and ventilating outside air.

In addition, a cooling method of a conventional Internet data center according to another example uses a general mechanical cooling cycle in which power is supplied to a compressor to compress a refrigerant, the compressed refrigerant discharges heat from a condenser, and an evaporator absorbs the heat.

In order to cool the discharge air of about 35°C generated inside the Internet data center, an individual air-cooled constant temperature and humidity unit is used, or a water-cooling method is used in which a cooling tower is installed outside and cooled cold water is supplied to the constant temperature and humidity unit to cool the interior, but the conventional cooling method has a problem that does not contribute to energy saving in that a compressor is assumed to consume a large amount of power, which accounts for the largest proportion of power usage of the constant temperature and humidity unit that has to operate 24 hours a day, 365 days a year.

In addition, there is a problem in the conventional technology that does not separately control only a hot zone, and also there is a problem in that, when a heat exchanger and a pipe through which a heat medium flows are damaged, IT equipment installed in a computer room is damaged by water because the water is used to cool the IT equipment.

Therefore, the importance of data centers is increasing due to the increase in Internet usage and the development of IT technology, and energy efficiency and cooling limitations of the known cooling system increase due to the high density of servers installed in a data center.

In the conventional technology, a space occupied by a machine room, a hot plenum, a hot zone, and a container for cooling a data center interior requires a large

area, and accordingly, it is impossible to individually respond to various load distributions for each server rack, and there is the risk of server short-circuiting or other accidents when a leakage occurs in a pipe of cooling equipment in a computer room.

Disclosure of Invention

Technical Problem

An objective of the present invention is to provide a server rack cooling system of a data center where a recovery line that is selectively opened is connected to a refrigerant circulation line through which a refrigerant circulates from dual refrigerant distribution units to a rear door cooling unit, and even when one refrigerant distribution unit is inoperable, another refrigerant distribution unit can circulate the refrigerant through the recovery line, and thus, operation continuity and operation reliability of a computer room can increase, and since there is no need for a hot zone space inside the computer room, space utilization is improved because a space is saved and a cooling space is reduced, and cooling energy efficiency can be increased through individual cooling load control because cooling load response is enabled for each server rack, and a working fluid of the rear door cooling unit is a refrigerant and implements a zero water system inside the computer room, and thus, even when a refrigerant leaks in the computer room, an information technology (IT) device is not damaged by water as the refrigerant evaporates, resulting in improvement of safety.

Solution to Problem

According to an aspect of the present invention, a server rack cooling system of a data center, the server rack cooling system includes a rear door cooling unit provided in a computer room of the data center, mounted on a server rack in which multiple servers are built in multiple stages, configured to cool a load heat generated from the server rack through heat exchange, and configured to discharge cooled server discharge air, a refrigerant distribution unit connected to the rear door cooling unit by a first refrigerant circulation line through which a first refrigerant circulates, configured to cool the first refrigerant circulating along the first refrigerant circulation line through heat exchange with cold water, and configured to circulate the first refrigerant, a free cooling refrigeration unit connected to the refrigerant distribution unit by a cold water circulation line through which the cold water circulates, configured to cool the cold water circulating along the cold water

circulation line through heat exchange, and configured to circulate the cold water, a recovery line including dual refrigerant distribution units and connecting the first refrigerant circulation lines of the dual refrigerant distribution units to each other, and a solenoid valve provided on the recovery line to selectively open and close the recovery line.

In this case, the rear door cooling unit may include a duct frame coupled to a rear surface of the server rack, a rear door case rotatably coupled to the duct frame by a hinge, a plurality of first heat exchangers provided inside the rear door case along a vertical length, configured to pass server discharge air discharged from the server rack therethrough, and configured to cool the server discharge air through heat exchange with the first refrigerant flowing therethrough, a blower provided behind each of the plurality of first heat exchangers and configured to blow the server discharge air passing through the plurality of first heat exchangers to an outside, and average temperature sensors respectively arranged before and after the plurality of first heat exchangers to measure temperature of the server discharge air before passing through the plurality of first heat exchangers and temperature of the server discharge air after passing through the plurality of first heat exchangers.

In addition, it is preferable that the first refrigerant is introduced into the plurality of first heat exchangers in a liquid state, changes into gas through heat exchange with the server discharge air, and is discharged from the plurality of first heat exchangers in a gaseous state.

Also, the server rack cooling system may further include a temperature sensor provided on a line, through which the first refrigerant is discharged from the rear door cooling unit to the refrigerant distribution unit, among the first refrigerant circulation lines, to measure discharge temperature of the first refrigerant, a pressure sensor provided on the line, through which the first refrigerant is discharged from the rear door cooling unit to the refrigerant distribution unit, among the first refrigerant circulation lines, to measure discharge pressure of the first refrigerant, and a refrigerant flow rate adjustment valve provided on a line, through which the first refrigerant is discharged from the rear door cooling unit to the refrigerant distribution unit, among the first refrigerant circulation lines, to selectively adjust opening on a discharge side of the first refrigerant circulation line.

In addition, the rear door cooling unit may perform an operation including: a step of opening the refrigerant flow rate adjustment valve while a fan of the blower is in operation to circulate the first refrigerant to the first heat exchanger along the first refrigerant circulation line, a step of measuring discharge temperature and discharge pressure of the first refrigerant circulating from the rear door cooling unit to the refrigerant distribution unit, a step of measuring inflow air dry bulb temperature wherein the inflow air is server discharge air flowing into the first heat exchanger and measuring exhaust air dry bulb temperature wherein the exhaust air is the server discharge air passing through the first heat exchanger, a step of gradually decreasing an operation rate of the fan of the blower when a difference between the measured inflow air dry bulb temperature and the exhaust air dry bulb temperature is less than set temperature, a step of gradually increasing the operation rate of the fan of the blower when the difference between the measured inflow air dry bulb temperature and the exhaust air dry bulb temperature is greater than the set temperature, a step of maintaining the operation rate of the fan of the blower when the difference between the measured inflow air dry bulb temperature and the exhaust air dry bulb temperature is equal to the set temperature, a step of calculating a superheat degree of the first refrigerant by using the measured discharge temperature of the first refrigerant and the measured discharge pressure of the first refrigerant, a step of gradually decreasing an opening rate of the refrigerant flow rate adjustment valve when the calculated superheat degree is less than the set superheat degree, a step of gradually increasing the opening rate of the refrigerant flow rate adjustment valve when the calculated superheat degree is greater than the set superheat degree, and a step of maintaining the opening rate of the refrigerant flow rate adjustment valve when the calculated superheat degree is equal to the set superheat degree.

In addition, the refrigerant distribution unit may include a first plate-shaped heat exchanger connecting the first refrigerant circulation line through which the first refrigerant circulates to the cold water circulation line through which the cold water circulates, and configured to cool and condense the first refrigerant through heat exchange with the cold water, a first reservoir tank connected to the first plate-shaped heat exchanger by the first refrigerant circulation line through which the first refrigerant circulates, receiving and accommodating the first refrigerant cooled and condensed by the first plate-shaped heat

exchanger, configured to separate a gaseous first refrigerant from a liquid first refrigerant, and configured to discharge the liquid first refrigerant, and a first refrigerant pump connected to the first reservoir tank by the first refrigerant circulation line through which the first refrigerant flows, configured to pump the liquid first refrigerant discharged from the first reservoir tank, and configured to transfer the liquid first refrigerant to the rear door cooling unit.

In this case, the refrigerant distribution unit may perform an operation including a step of operating the first refrigerant pump to circulate the first refrigerant along the first refrigerant circulation line, a step of measuring discharge temperature and discharge pressure of the first refrigerant circulating along the first refrigerant circulation line;

a step of calculating a cold water side cooling load, a step of gradually increasing an opening rate of an energy valve when the calculated cold water side cooling load is less than a set cold water side cooling load, a step of gradually decreasing the opening rate of the energy valve when the calculated cold water side cooling load is greater than the set cold water side cooling load, a step of maintaining the opening rate of the energy valve when the calculated cold water side cooling load is equal to the set cold water side cooling load, a step of calculating a subcooling degree of the first refrigerant by using the measured discharge temperature of the first refrigerant and the measured discharge pressure of the first refrigerant, a step of gradually decreasing an operation rate of the first refrigerant pump when the calculated subcooling degree is less than a set subcooling degree, a step of gradually increasing the operation rate of the first refrigerant pump when the calculated subcooling degree is greater than the set subcooling degree, and a step of maintaining the operation rate of the first refrigerant pump when the calculated subcooling degree is equal to the set subcooling degree.

Also, the dual refrigerant distribution units may perform a recovery operation including a step of starting a heartbeat communication with each refrigerant distribution unit when the dual refrigerant distribution unit starts to operate, and checking whether a normal communication is performed, a step of maintaining a closed state of the solenoid valve when the heartbeat communication is performed normally, and a step of opening the solenoid valve on a side where the normal communication is performed when any one of the dual refrigerant distribution units fails to perform the normal communication

during the heartbeat communication of the dual refrigerant distribution units, to circulate the first refrigerant to the rear door cooling unit on a side where the normal communication is not performed.

In addition, the free cooling refrigeration unit may include a free cooling portion configured to cool the cold water through heat exchange with a second refrigerant cooled by outside air, a refrigeration unit connected to the free cooling portion and configured to cool the cold water through heat exchange with a third refrigerant that repeats evaporation, compression, condensation, and expansion processes, a cold water tank connected to the refrigeration portion by the cold water circulation line through which the cold water circulates and receiving and accommodating the cold water cooled by the refrigeration portion, and a water pump connected to the cold water tank by the cold water circulation line through which the cold water circulates, and configured to transfer the cold water accommodated in the cold water tank to the refrigerant distribution unit.

In this case, the free cooling portion may include a second plate-shaped heat exchanger connecting the cold water circulation line through which the cold water circulates to a second refrigerant circulation line through which a second refrigerant circulates, and configured to cool the cold water through heat exchange with the second refrigerant, a second heat exchanger connected to the second plate-shaped heat exchanger by the second refrigerant circulation line through which the second refrigerant circulates, receiving the second refrigerant heat-exchanged with the cold water, and configured to cool the received second refrigerant through heat exchange with the outside air, a second reservoir tank connected to the second heat exchanger by the second refrigerant circulation line through which the second refrigerant circulates and receiving and accommodating the second refrigerant cooled by the second heat exchanger, and a second refrigerant pump connected to the second reservoir tank by the second refrigerant circulation line through which the second refrigerant circulates and transferring the second refrigerant accommodated in the second reservoir tank to the second plate-shaped heat exchanger.

In addition, the refrigeration portion may include a third plate-shaped heat exchanger connected to the cold water circulation line through which the cold water circulates and a third refrigerant circulation line through which a third refrigerant circulates

and configured to cool the cold water through heat exchange with the third refrigerant, an accumulator connected to the third plate-shaped heat exchanger by the third refrigerant circulation line through which the third refrigerant circulates, receiving the third refrigerant discharged from the third plate-shaped heat exchanger, configured to separate the third refrigerant into a liquid third refrigerant and a gaseous third refrigerant, and configured to discharge the gaseous third refrigerant to a compressor, the compressor connected to the accumulator by the third refrigerant circulation line through which the third refrigerant circulates, configured to compress the gaseous third refrigerant discharged from the accumulator, and configured to discharge the third refrigerant with high temperature and high pressure, an oil separator connected to the compressor by the third refrigerant circulation line through which the third refrigerant circulates, configured to remove oil from the third refrigerant discharged from the compressor, and configured to discharge the third refrigerant from which the oil is removed, a condenser connected to the oil separator by the third refrigerant circulation line through which the third refrigerant circulates, configured to condense the third refrigerant, which is discharged from the oil separator, through heat exchange with the outside air, and configured to discharge the condensed third refrigerant, a third reservoir tank connected to the condenser by the third refrigerant circulation line through which the third refrigerant circulates and receiving and accommodating the third refrigerant condensed by the condenser, a strainer connected to the third reservoir tank by the third refrigerant circulation line through which the third refrigerant circulates and configured to remove foreign substances included in the third refrigerant discharged from the third reservoir tank, and an electronic expansion valve connected to the strainer by the third refrigerant circulation line through which the third refrigerant circulates, receiving the third refrigerant passing through the strainer, configured to expand the third refrigerant, and configured to discharge the expanded third refrigerant to the third plate-shaped heat exchanger.

In add, the free cooling refrigeration unit may perform an operation including a step of operating only the refrigeration portion in a cooling mode, a step of receiving a compressor inverter operation value of the refrigeration portion, a step of comparing the received compressor inverter operation value with a set dual conversion compressor inverter operation value and maintaining the cooling mode when the compressor inverter

operation value is greater than the set dual conversion compressor inverter operation value, a step of comparing the received compressor inverter operation value with the set dual conversion compressor inverter operation value and converting into a dual mode when the compressor inverter operation value is less than the set dual conversion compressor inverter operation value, a step of operating both the refrigeration portion and the free cooling portion in a dual mode, a step of comparing the received compressor inverter operation value with a set free cooling conversion compressor inverter operation value and maintaining the cooling mode when the compressor inverter operation value of the refrigeration portion is greater than the set free cooling conversion compressor inverter operation value, a step of comparing the received compressor inverter operation value with the set free cooling conversion compressor inverter operation value and converting into a free cooling mode when the compressor inverter operation value is less than the set free cooling conversion compressor inverter operation value, a step of operating only the free cooling portion in the free cooling mode, a step of measuring inflow temperature of the cold water circulating to the refrigerant distribution unit and discharge temperature of the cold water, a step of converting back to the dual mode when a difference between the measured inflow temperature of the cold water and the measured discharge temperature of the cold water is less than a set minimum cold water temperature, and a step of maintaining the free cooling mode when the difference between the measured inflow temperature of the cold water and the measured discharge temperature of the cold water is less than the set minimum cold water temperature.

Advantageous Effects of Invention

A server rack cooling system of a data center according to the present invention has the following effects.

A recovery line that is selectively opened is connected to a refrigerant circulation line through which a refrigerant circulates from dual refrigerant distribution units to a rear door cooling unit, and even when one refrigerant distribution unit is inoperable, another refrigerant distribution unit can circulate the refrigerant through the recovery line, and thus, operation continuity and operation reliability of a computer room can increase.

Since there is no need for a hot zone space inside the computer room, space utilization is improved because a space is saved and a cooling space is reduced, and

cooling energy efficiency can be increased through individual cooling load control because cooling load response is enabled for each server rack.

A working fluid of the rear door cooling unit is a refrigerant and implements a zero water system inside the computer room, and thus, even when a refrigerant leaks in the computer room, an information technology (IT) device is not damaged by water as the refrigerant evaporates, resulting in improvement of safety.

An energy-efficient cooling systems can be implemented by utilizing multiple heat sources.

Cooling units that can be used for each server rack can operate independently, and thus, energy of a cooling system can be saved.

Brief Description of Drawings

FIG. 1 is a block diagram schematically illustrating a server rack cooling system of a data center according to an embodiment of the present invention.

FIG. 2 is a block diagram schematically illustrating a rear door cooling unit of a server rack cooling system of a data center according to an embodiment of the present invention.

FIG. 3 is a perspective view schematically illustrating a rear door cooling unit according to an embodiment of the present invention.

FIG. 4 is a cross-sectional view schematically illustrating a rear door cooling unit according to an embodiment of the present invention.

FIG. 5 is a block diagram schematically illustrating a refrigerant distribution unit of a server rack cooling system of a data center according to an embodiment of the present invention.

FIG. 6 is a block diagram schematically illustrating a dual refrigerant distribution unit and a recovery line according to an embodiment of the present invention.

FIG. 7 is an example diagram illustrating an example of using a recovery line according to an embodiment of the present invention.

FIG. 8 is a block diagram schematically illustrating a free cooling refrigeration unit of a server rack cooling system of a data center according to an embodiment of the present invention.

FIG. 9 is a block diagram sequentially illustrating an operation logic of a rear door cooling unit of a server rack cooling system of a data center according to an embodiment of the present invention.

FIG. 10 is a block diagram sequentially illustrating an operation logic of a refrigerant distribution unit of a server rack cooling system of a data center according to an embodiment of the present invention.

FIG. 11 is a block diagram sequentially illustrating a recovery operation logic of a refrigerant distribution unit according to an embodiment of the present invention.

FIG. 12 is a block diagram sequentially illustrating an operation logic of a free cooling refrigeration unit of a server rack cooling system of a data center according to an embodiment of the present invention.

Mode for Carrying out the Invention

Hereinafter, preferred embodiments according to the present invention will be described in detail with reference to the attached drawings. In order to describe the present invention, terms or words used in the specification and claims should not be interpreted as limited to their usual or dictionary meanings, and should be interpreted as meanings and concepts that conform to the technical idea of the present invention based on a principle that the inventor can appropriately define the concepts of the terms to explain his or her own invention in the best way.

Therefore, embodiments described in the specification and configurations illustrated in the drawings are merely preferred embodiments of the present invention, and do not represent all of the technical ideas of the present invention, and accordingly, it should be understood that there can be equivalent modified examples that can be replaced at the time of the application.

The present invention provides a server rack cooling system of a data center that does not require a hot zone space inside a computer room, can implement a zero water system inside the computer room, and has high energy efficiency as cooling devices that can be supported by each server rack are independently controlled, as illustrated in the drawings.

A server rack cooling system of a data center according to an embodiment of the present invention illustrated in FIGS. 1 to 8 includes a rear door cooling unit 100, a refrigerant distribution unit 200, and a free cooling refrigeration unit 300.

The rear door cooling unit 100 is installed in a computer room of a data center and is mounted on a server rack in which multiple servers are built in multiple stages, cools the load heat generated from the server rack through heat exchange, and discharges the cooled server discharge air into the computer room.

In this case, a server rack 10 includes IT equipment such as a server built in an internal space of the server rack 10, and multiple server racks 10 are arranged in multiple rows in a computer room, and the server rack 10 has a rectangular shape in which a height is greater than a width and length, like a general server rack, and IT equipment such as a server is built in multiple stages inside the server rack 10.

It is preferable to form an inlet on the front side or the left and right sides of the server rack 10 to allow the indoor air of a computer room to be introduced, and it is preferable to open a rear surface of the server rack 10 such that communication lines (LAN lines) and power lines are connected to the IT equipment.

In addition, a duct frame 110 is coupled to the rear side surface of the server rack 10 and has a quadrangle frame shape corresponding to the rear side surface of the server rack 10 and has an opening through which air of the server rack 10 can flow.

In addition, a cooling unit 120 is coupled to the duct frame 110 to cool the server discharge air discharged from the inside of the server rack 10, and accordingly, the cooled server discharge air is discharged into a computer room.

The cooling unit 120 according to an embodiment of the present invention will be described in more detail as follows.

The cooling unit 120 includes a rear door case 121, a plurality of first heat exchangers 122, a partition wall 123, and blowers 124, and the rear door case 121 is coupled to the rear of the duct frame 110 to open and close the opening of the duct frame 110.

In this case, a part of a rear surface of the rear door case 121 can be formed of a perforated plate so as not to impede the flow of air, and the rear surface of the rear door case 121 has a rectangular shape in which a height is greater than a width and a length

to correspond to a rear shape of the duct frame 110, and a front surface communicating with a rear surface of the duct frame 110 forms an open surface, and the rear surface of the rear door case 121 also forms an open surface.

Here, a width of the open surface on the rear surface side of the rear door case 121 is less than an open surface on a front surface side of the rear door case 121, and it is preferable that the width of the open surface on the rear surface side of the rear door case 121 is less than half of the width of the open surface on the front surface side of the rear door case 121.

In addition, one side of the front surface of the rear door case 121 is connected to one side of the rear surface of the duct frame 110 by a hinge.

Here, the rear surface of the rear door case 121 is connected to a distribution panel accommodation frame 1211, and the distribution panel accommodation frame 1211 has a horizontal cross section of a '⊏' shape and is detachably coupled to the rear surface of the rear door case 121, and a plurality of distribution panels electrically connected to the blowers 124 and rear sides of the blowers 124 are accommodated in an internal space of the rear surface of the rear door case 121.

The plurality of distribution panels supply power to the blowers 124 in response to signals from a control unit to control on/off of the blowers 124 and rotation speeds of fans.

In addition, the plurality of first heat exchangers 122 are provided in a front inside of the rear door case 121 and are arranged at regular intervals along a vertical length in an internal space of the rear door case 121 such that the plurality of first heat exchangers 122 can be provided in partitioned internal spaces of the server rack 10 to correspond to the number of partitioned internal spaces.

A liquid first refrigerant circulates inside the stacked cooling fins of the plurality of first heat exchangers 122, and the first refrigerant circulating through the plurality of first heat exchangers 122 absorbs heat of the server discharge air flowing between the cooling fins by changing heat with the server discharge air, and accordingly, the server discharge air discharged from the inside of the server rack 10 is cooled.

In this case, the plurality of first heat exchangers 122 are arranged at regular intervals along a vertical length in the front of the rear door case 121, and each of the plurality of first heat exchangers 122 is connected to a first refrigerant circulation line 1.

It is preferable that the first refrigerant circulation line 1 is divided into an inflow pipe and a discharge pipe such that the first refrigerant can circulate, and the first refrigerant transferred from the refrigerant distribution unit 200 is introduced into the plurality of first heat exchangers 122 along the first refrigerant circulation line 1, and then the first refrigerant discharged from the plurality of first heat exchangers 122 circulates back to the refrigerant distribution unit 200.

Here, the first refrigerant circulation line 1 is connected in parallel to the plurality of first heat exchangers 122 and can operate selectively and individually the plurality of first heat exchangers 122.

A partition wall 123 is located behind the plurality of first heat exchangers 122 in the internal space of the rear door case 121 and has a plate shape, and through-holes are formed at regions corresponding to positions of the plurality of first heat exchangers 122.

The blowers 124 are respectively provided in the through-holes of the partition wall 123 and are respectively provided at the rears of the through-hole formed in the partition wall 123 to blow air such that air passing through the plurality of first heat exchangers 122 is discharged to the outside.

In this case, the blowers 124 are electrically connected to the distribution panel, and operations of the blowers 124 are controlled by the power selectively output from the distribution panel.

In addition, average temperature sensors 125 are provided before and after the plurality of first heat exchangers 122, and the average temperature sensors 125 measure the temperature of the server discharge air before passing through the plurality of first heat exchangers 122 and the server discharge air passing through the plurality of first heat exchangers 122.

In this case, the average temperature sensors 125 are electrically connected to the control unit to measure the temperature of the server discharge air discharged from

the corresponding server rack 10, and transmit the measured temperature to the control unit.

Here, the control unit generates a control signal based on the temperature of the server discharge air measured by the average temperature sensors 125, and when the control signal is applied to the distribution panel, the distribution panel controls fan speeds of the blowers 124.

In addition, a temperature sensor 131 and a pressure sensor 132 that respectively measure the discharge temperature and discharge pressure of the first refrigerant are provided on a line, through which the first refrigerant is discharged from the rear door cooling unit 100 to the refrigerant distribution unit 200, among the first refrigerant circulation lines 1, and a refrigerant flow rate adjustment valve 133 that adjusts a discharge side opening of the first refrigerant circulation line 1 is provided to adjust an opening of the refrigerant flow rate adjustment valve 133 based on the discharge temperature and discharge pressure of the first refrigerant measured by the temperature sensor 131 and the pressure sensor 132.

That is, the opening of the refrigerant flow rate adjustment valve 133 is adjusted according to a load heat amount for each server rack 10.

In addition, it is preferable that a plurality of the rear door cooling units 100 are provided to be respectively included in the server racks 10.

The refrigerant distribution unit 200 recovers the heat of the first refrigerant circulating through the plurality of rear door cooling units 100 connected in parallel through heat exchange with cold water, condenses the first refrigerant, and circulates the cooled and condensed first refrigerant back to the rear door cooling unit 100.

In this case, the cold water circulating through the refrigerant distribution unit 200 exchanges heat with the first refrigerant, which is an operating fluid of the rear door cooling unit 100, in a first plate-shaped heat exchanger 210, thereby cooling and condensing the first refrigerant.

The refrigerant distribution unit 200 includes the first plate-shaped heat exchanger 210, a first reservoir tank 220, and a first refrigerant pump 230.

The first plate-shaped heat exchanger 210 exchanges heat between cold water and a gaseous first refrigerant, such that the gaseous first refrigerant is cooled and condensed and changes into the liquid first refrigerant.

Therefore, the first plate-shaped heat exchanger 210 includes a cold water circulation line 2, through which cold water flows, overlapping a first refrigerant circulation line 1 through which the first refrigerant circulates, and accordingly, heat is exchanged between the cold water flowing along the first plate-shaped heat exchanger 210 and the gaseous first refrigerant.

In addition, the first reservoir tank 220 is connected to the first plate-shaped heat exchanger 210 through the first refrigerant circulation line 1 through which the first refrigerant circulates, and receives and stores the liquid first refrigerant that is changed in phase and is cooled and condensed through heat exchange with cold water by the first plate-shaped heat exchanger 210.

In this case, the first reservoir tank 220 separates the gaseous first refrigerant that is not completely changed in phase by the first plate-shaped heat exchanger 210 from the liquid first refrigerant and discharges only the liquid first refrigerant.

The first refrigerant pump 230 is connected to the first reservoir tank 220 through the first refrigerant circulation line 1 through which the first refrigerant flows, and pumps the liquid first refrigerant discharged from the first reservoir tank 220 and transfers the first refrigerant to the rear door cooling unit 100.

In addition, among the cold water circulation lines 2 connected to the first plate-shaped heat exchanger 210, cold water temperature sensors 241 and 242 for respectively measuring the inflow temperature and discharge temperature of cold water are respectively provided on an inflow side where the cold water flows into the first plate type heat exchanger 210 and on a discharge side where the cold water is discharged from the first plate type heat exchanger 210, an energy valve 243 is provided on the side of the cold water circulation line 2 which discharges the cold water from the refrigerant distribution unit 200 to a free cooling refrigeration unit 300, and accordingly, opening of the energy valve 243 is controlled based on the inflow and discharge temperatures of the cold water measured by the cold water temperature sensors 241 and 242.

In addition, the server rack cooling system of the data center according to the embodiment of the present invention is provided with dual refrigerant distribution units 200 which are respectively connected to rear door cooling units 100 in charge (supplying the first refrigerant) through the first refrigerant circulation lines 1 to form a group.

In this case, the first refrigerant circulation lines 1 respectively connected to the refrigerant distribution units 200 and the rear door cooling units 100) include recovery lines 250 and 260, discharge sides of the refrigerant distribution units 200 that cause the first refrigerants to flow from the refrigerant distribution units 200 to the rear door cooling units 100 are connected to the recovery discharge line 250, and inflow sides of the refrigerant distribution units 200 that cause the first refrigerants to flow from the rear door cooling units 100 to the refrigerant distribution units 200 are connected to the recovery inflow line 260.

The recovery discharge line 250 and the recovery inflow line 260 are each branched into two lines, and the branched recovery discharge lines 250 and the branched recovery inflow lines 260 are respectively provided with solenoid valves 251, 252, 261, and 262, and the recovery discharge line 250 and the recovery inflow line 260 are open due to opening transition of the solenoid valves 251, 252, 261, and 262, and accordingly, the first refrigerant flows.

For example, when one of the dual refrigerant distribution units 200 fails and can not operate, the solenoid valves 261 and 262 that are operable are open, such that the recovery discharge line 250 and the recovery inflow line 260 that are operable are open, and accordingly, the first refrigerant also circulates to the rear door cooling units 100 corresponding to the refrigerant distribution units 200, which are not operable, through the recovery discharge line 250 and the recovery inflow line 260 that are open on the side of the refrigerant distribution unit 200 that can perform a normal operation.

Here, the dual refrigerant distribution units 200 communicate periodically with a heartbeat communication unit, and when one of the dual refrigerant distribution units 200 is communicably disconnected from the heartbeat communication unit, the refrigerant distribution unit 200 communicating with the heartbeat communication unit is connected to the solenoid valves 251, 252, 261, and 262, and based on this, the refrigerant distribution unit 200 can switch the solenoid valves 251, 252, 261, and 262 to open.

In addition, the free cooling refrigeration unit 300 provides cold heat to the cold water circulating through the refrigerant distribution unit 200 and circulates the cooled cold water back to the refrigerant distribution unit 200.

In this case, the free cooling refrigeration unit 300 includes a free cooling portion 400, a refrigeration portion 500, a cold water tank 310 that accommodates the cold water cooled by the free cooling portion 400 and the refrigeration portion 500, and a water pump 320 that transfers the cold water accommodated in the cold water tank 310 to the refrigerant distribution unit 200.

In addition, the free cooling portion 400 cools the second refrigerant through heat exchange with the outside air to obtain cold heat for cooling the cold water circulating in the refrigerant distribution unit 200.

Here, the free cooling portion 400 includes a second plate-shaped heat exchanger 410, a second heat exchanger 420, a second reservoir tank 430, and a second refrigerant pump 440.

The second plate-shaped heat exchanger 410 cools the cold water circulating through the refrigerant distribution unit 200 by introducing the cold water and exchanging heat with the second refrigerant, and the cold water circulating through the refrigerant distribution unit 200 passes through one side of the second plate-shaped heat exchanger 410, and the second refrigerant passes through the other side of the second plate-shaped heat exchanger 410.

Therefore, the second plate-shaped heat exchanger 410 includes the cold water circulation line 2, through which cold water flows, overlapping the second refrigerant circulation line 3 through which the second refrigerant circulates, and accordingly, the cold water flowing through the second plate-shaped heat exchanger 410 is cooled through heat exchange with the second refrigerant, and the cooled cold water is discharged to the refrigeration portion 500.

In addition, the second heat exchanger 420 cools the second refrigerant with outside air (external air), is connected to the second plate-shaped heat exchanger 410 by the second refrigerant circulation line 3 through which the second refrigerant circulates, receives the second refrigerant heat-exchanged with cold water in the second plate-

shaped heat exchanger 410, cools the received second refrigerant through heat exchange (air cooling) with the outside air, and discharges the cooled second refrigerant.

In this case, the second heat exchanger 420 is equipped with a blower fan to selectively adjust the blowing amount of outside air.

In addition, the second reservoir tank 430 accommodates the second refrigerant heat-exchanged with the outside air, is connected to the second heat exchanger 420 by the second refrigerant circulation line 3 through which the second refrigerant circulates, and receives and accommodates the second refrigerant cooled through heat exchange with the outside air in the second heat exchanger 420.

In addition, the second refrigerant pump 440 is for transferring by pressure the second refrigerant accommodated in the second reservoir tank 430, is connected to the second reservoir tank 430 by the second refrigerant circulation line 3 through which the second refrigerant circulates, and transfers the second refrigerant accommodated in the second reservoir tank 430 to the second plate-shaped heat exchanger 410.

The refrigeration portion 500 obtains cold heat by performing mechanical refrigerating operation (evaporation-compression-condensation-expansion of refrigerant) by operating a compressor, is connected to the free cooling portion 400 by the cold water circulation line 2 through which cold water circulates, and cools the cold water through heat exchange with a third refrigerant in the refrigeration portion 500.

The refrigeration portion 500 obtains cold heat for cooling the cold water passing through the free cooling portion 400 through an evaporation action of the third refrigerant.

In this case, the refrigeration portion 500 includes a third plate-shaped heat exchanger 510, a compressor 530, a condenser 550, and an electronic expansion valve 580. The third plate-shaped heat exchanger 510 cools cold water by receiving the cold water circulating through the free cooling portion 400 and by exchanging heat with a third refrigerant. The cold water from the free cooling portion 400 passes through one side of the third plate-shaped heat exchanger 510, and the third refrigerant passes through the other side of the third plate-shaped heat exchanger 510.

In this case, the third plate-shaped heat exchanger 510 includes a third refrigerant circulation line 4, through which the third refrigerant circulates, overlapping the cold water circulation line 2 through which cold water flows, and the cold water flowing through the

third plate-shaped heat exchanger 510 is cooled through heat exchange with the third refrigerant, and the cooled cold water is discharged to the refrigerant distribution unit 200.

Here, the third plate-shaped heat exchanger 510 provides the cold water with the cold air generated due to evaporation of the third refrigerant to enable the cold water to be cooled.

In addition, the third plate-shaped heat exchanger 510 is connected to an accumulator 520. The accumulator 520 is connected to the third plate-shaped heat exchanger 510 by the third refrigerant circulation line 4 through which the third refrigerant circulates, and receives the third refrigerant discharged from the third plate-shaped heat exchanger 510, separates the third refrigerant into a liquid refrigerant and a gaseous refrigerant, and then discharges the gaseous refrigerant to the compressor 530.

The compressor 530 is connected to the accumulator 520 by the third refrigerant circulation line 4 through which the third refrigerant circulates, compresses the gaseous refrigerant discharged from the accumulator 520, and discharges a high-temperature and high-pressure refrigerant.

In this case, an oil separator 540 is provided in a discharge end of the compressor 530, is connected to the compressor 530 by the third refrigerant circulation line 4 through which the third refrigerant circulates, removes oil from the refrigerant discharged from the compressor 530, and discharges the refrigerant from which the oil is removed.

In addition, the third refrigerant discharged from the oil separator 540 flows into the condenser 550. The condenser 550 is connected to the oil separator 540 by the third refrigerant circulation line 4 through which the third refrigerant circulates, condenses the third refrigerant discharged from the separator 540 and discharges the condensed third refrigerant.

In this case, the condenser 550 condenses the third refrigerant by using the outside air, is connected to the oil separator 540 by the third refrigerant circulation line 4 through which the third refrigerant circulates, receives the third refrigerant discharged from the oil separator 540, condenses the received third refrigerant through heat exchange with the outside air, and discharges the condensed third refrigerant.

In this case, the condenser 550 is equipped with a blower fan to enable the blowing amount of outside air to be selectively adjusted.

The third refrigerant discharged from the condenser 550 is accommodated in the third reservoir tank 560. The third reservoir tank 560 accommodates the third refrigerant condensed through heat exchange with the outside air, is connected to the condenser 550 by the third refrigerant circulation line 4 through which the third refrigerant circulates, and receives and accommodates the third refrigerant condensed through heat exchange with the outside air in the condenser 550.

In addition, the third reservoir tank 560 is connected to a strainer 570 by a third refrigerant circulation line 4 through which the third refrigerant circulates, and the strainer 570 removes foreign substances from the third refrigerant discharged from the third reservoir tank 560.

The third refrigerant passing through the strainer 570 flows to the electronic expansion valve 580. The electronic expansion valve 580 is connected to the strainer 570 by the third refrigerant circulation line 4 through which the third refrigerant circulates, receives the third refrigerant passing through the strainer 570, expands the third refrigerant, and discharges the expanded third refrigerant to the third plate-shaped heat exchanger 510.

Therefore, the third refrigerant introduced into the third plate-shaped heat exchanger 510 can cool the cold water by using the generated cold air that evaporates.

Referring to FIGS. 9 to 12, operation processes of the rear door cooling unit 100, the refrigerant distribution unit 200, and the free cooling refrigeration unit 300 that constitute the server rack cooling system of the data center according to the embodiment of the present invention, according to control logics, are sequentially provided as follows.

First, referring to FIG. 9, in the operation process of the rear door cooling unit 100, when an operation of the rear door cooling unit 100 starts, a fan of the blower 124 operates to open the refrigerant flow rate adjustment valve 133, and thereby, a first refrigerant circulates through the first heat exchanger 122 along the first refrigerant circulation line 1.

Here, when the first refrigerant circulates along the first refrigerant circulation line 1, discharge temperature T_r and discharge pressure P_r of the first refrigerant are measured respectively by the temperature sensor 131 and the pressure sensor 132

provided on a line where the first refrigerant is discharged from the rear door cooling unit 100 to the refrigerant distribution unit 200 among the first refrigerant circulation lines 1.

Next, inflow air dry bulb temperature T_{in} wherein the inflow air is server discharge air flowing into the first heat exchanger 122, and exhaust air dry bulb temperature T_{out} wherein the exhaust air is the server discharge air passing through the first heat exchanger 122 are measured.

In this case, when a difference value between the inflow air dry bulb temperature T_{in} and the exhaust air dry bulb temperature T_{out} is less than set temperature T_{set} , a fan of the blower 124 gradually decreases an operation rate, and the difference value between the inflow air dry bulb temperature T_{in} and the exhaust air dry bulb temperature T_{out} is greater than the set temperature T_{set} , the fan of the blower 124 gradually increases the operation rate, and the difference value between the inflow air dry bulb temperature T_{in} and the exhaust air dry bulb temperature T_{out} is equal to the set temperature T_{set} , the fan of the blower 124 maintains the operation rate.

In addition, a superheat degree $T_{superheat}$ of the first refrigerant is calculated by the discharge temperature T_r and the discharge pressure P_r of the measured first refrigerant.

In this case, when the calculated superheat degree $T_{superheat}$ is less than a set superheat $T_{superheat-set}$, an opening rate of the refrigerant flow rate adjustment valve 133 gradually decreases, and when the calculated superheat degree $T_{superheat}$ is greater than the set superheat $T_{superheat-set}$, the opening rate of the refrigerant flow rate adjustment valve 133 gradually increases, and when the calculated superheat degree $T_{superheat}$ is equal to the set superheat $T_{superheat-set}$, the opening rate of the refrigerant flow rate adjustment valve 133 is maintained.

Referring to FIG. 10, in the operation process of the refrigerant distribution unit 200, when an operation of the refrigerant distribution unit 200 starts, the first refrigerant pump 230 starts operation, and the discharge temperature T_r and the discharge pressure P_r of the first refrigerant are measured respectively by the temperature sensor 131 and the pressure sensor 132 provided on the first refrigerant circulation line 1 through which the first refrigerant circulates.

Next, a cooling load Q_{load} on a cold water side is calculated.

In this case, when the calculated cold water side cooling load Q_{load} is less than a set cold water side cooling load $Q_{load-set}$, an opening rate of an energy valve gradually increases, and when the calculated cold water side cooling load Q_{load} is greater than the set cold water side cooling load $Q_{load-set}$, the opening rate of the energy valve gradually decreases, and when the calculated cold water side cooling load Q_{load} is equal to the set cold water side cooling load $Q_{load-set}$, the opening rate of the energy valve is maintained.

Then, a subcool degree $T_{subcool}$ of the first refrigerant is calculated by the discharge temperature T_r and the discharge pressure P_r of the measured first refrigerant.

In this case, when the calculated subcool degree $T_{subcool}$ is less than the set subcool degree $T_{subcool-set}$, an operation rate of the first refrigerant pump 230 gradually decreases, and when the calculated subcool degree $T_{subcool}$ is greater than the set subcool degree $T_{subcool-set}$, the operation rate of the first refrigerant pump 230 increases gradually, and when the calculated subcool degree $T_{subcool}$ is equal to the set subcool degree $T_{subcool-set}$, the operation rate of the first refrigerant pump 230 is maintained.

Here, dual refrigerant distribution units 200 are provided, and accordingly, when one of the refrigerant distribution units 200 fails to be inoperable, the first refrigerant is automatically supplied to inoperable rear door cooling units 100 from the other refrigerant distribution unit 200.

Referring to FIG. 11, in the recovery operation process of the dual refrigerant distribution units 200, when operations of the dual refrigerant distribution unit 200 start, a heartbeat communication starts in the dual refrigerant distribution units 200, and it is checked whether a normal communication is performed.

In this case, when the heartbeat communication is performed normally, the solenoid valves 251, 252, 261, and 262 provided on the recovery discharge line 250 and the recovery inflow line 260 are maintained in a closed state.

In addition, when the heartbeat communication of any one of the refrigerant distribution unit 200 is not performed normally, the solenoid valves 251, 252, 261, and 262 on a side where the normal communication is performed are opened, and accordingly, the recovery discharge line 250 and the recovery inflow line 260 on the side where the normal communication is performed are opened, and the first refrigerant circulates from the refrigerant distribution unit 200 on the side where the normal communication is

performed to the rear door cooling units 100 connected to the refrigerant distribution unit 200 on the side where the normal communication is performed.

Referring to FIG. 12, in the operation process of the free cooling refrigeration unit 300, when an operation of the free cooling refrigeration unit 300 starts, a cooling mode is executed first.

In the cooling mode, only the refrigeration portion 500 of the free cooling refrigeration unit 300 operates and receives a compressor inverter operation value P_{comp} of the refrigeration portion 500.

In this case, when the compressor inverter operation value P_{comp} is greater than a set dual conversion compressor inverter operation value $P_{comp \text{ to dual set}}$, the cooling mode is maintained, and when the compressor inverter operation value P_{comp} is less than the set dual conversion compressor inverter operation value $P_{comp \text{ to dual set}}$, the cooling mode is converted into a dual mode.

In the dual mode, the cooling mode and a free cooling mode are operated together, that is, the free cooling portion 400 and the refrigeration portion 500 operate together.

In this case, when the compressor inverter operation value P_{comp} of the refrigeration portion 500 is greater than a set free cooling conversion compressor inverter operation value $P_{dual \text{ to free set}}$, the dual mode is maintained, and when the compressor inverter operation value P_{comp} of the refrigeration portion 500 is less than the set free cooling conversion compressor inverter operation value $P_{dual \text{ to free set}}$, the dual mode is converted into the free cooling mode.

In the free cooling mode, only the free cooling portion 400 operates, and inflow temperature T_{in} and discharge temperature T_{out} cold water circulating along the cold water circulation line 2 to the refrigerant distribution unit 200 are measured by the cold water temperature sensors 241 and 242.

In this case, when a difference value between the inflow temperature T_{in} and the discharge temperature T_{out} is less than a set minimum cold water temperature $T_{minimum-set}$, the free cooling mode is converted back into the dual mode.

When the difference value between the inflow temperature T_{in} and the discharge temperature T_{out} is less than the set minimum cold water temperature $T_{minimum-set}$, the free cooling mode is maintained.

Although the present invention is described with reference to the embodiments illustrated in the drawings, these are merely examples, and those skilled in the art will understand that various modifications and equivalent other embodiments can be derived therefrom. Therefore, the true technical protection scope of the present invention should be determined by the technical idea of the appended patent claims.

Reference Signs List

1: first refrigerant circulation line	2: cold water circulation line
3: second refrigerant circulation line	4: third refrigerant circulation line
10: server rack	100: rear door cooling unit
110: duct frame	120: cooling unit
121: rear door case	122: first heat exchanger
123: partition wall	124: blower
125: average temperature sensor	131: temperature sensor
132: pressure sensor	133: refrigerant flow rate adjustment valve
200: refrigerant distribution unit	210: first plate-shaped heat exchanger
220: first reservoir tank	230: first refrigerant pump
241, 242: cold water temperature sensor	243: energy valve
250: recovery discharge line	251, 252, 261, 262: solenoid valve
260: recovery inflow line	300: free cooling refrigeration unit
310: cold water tank	320: water pump
400: free cooling portion	410: second plate-shaped heat exchanger
420: second heat exchanger	430: second reservoir tank
440: second refrigerant pump	500: refrigeration portion
510: third plate-shaped heat exchanger	520: accumulator
530: compressor	540: oil separator
550: condenser	560: third reservoir tank
570: strainer	580: electronic expansion valve

CLAIMS

1. A server rack cooling system of a data center, the server rack cooling system comprising:

a rear door cooling unit provided in a computer room of the data center, mounted on a server rack in which multiple servers are built in multiple stages, configured to cool a load heat generated from the server rack through heat exchange, and configured to discharge cooled server discharge air;

a refrigerant distribution unit connected to the rear door cooling unit by a first refrigerant circulation line through which a first refrigerant circulates, configured to cool the first refrigerant circulating along the first refrigerant circulation line through heat exchange with cold water, and configured to circulate the first refrigerant;

a free cooling refrigeration unit connected to the refrigerant distribution unit by a cold water circulation line through which the cold water circulates, configured to cool the cold water circulating along the cold water circulation line through heat exchange, and configured to circulate the cold water;

a recovery line including dual refrigerant distribution units and connecting the first refrigerant circulation lines of the dual refrigerant distribution units to each other; and

a solenoid valve provided on the recovery line to selectively open and close the recovery line.

2. The server rack cooling system of the data center of claim 1, wherein the rear door cooling unit includes:

a duct frame coupled to a rear surface of the server rack;

a rear door case rotatably coupled to the duct frame by a hinge;

a plurality of first heat exchangers provided inside the rear door case along a vertical length, configured to pass server discharge air discharged from the server rack therethrough, and configured to cool the server discharge air through heat exchange with the first refrigerant flowing therethrough;

a blower provided behind each of the plurality of first heat exchangers and configured to blow the server discharge air passing through the plurality of first heat exchangers to an outside; and

average temperature sensors respectively arranged before and after the plurality of first heat exchangers to measure temperature of the server discharge air before passing through the plurality of first heat exchangers and temperature of the server discharge air after passing through the plurality of first heat exchangers.

3. The server rack cooling system of the data center of claim 2, wherein the first refrigerant is introduced into the plurality of first heat exchangers in a liquid state, changes into gas through heat exchange with the server discharge air, and is discharged from the plurality of first heat exchangers in a gaseous state.

4. The server rack cooling system of the data center of claim 3, further comprising:

a temperature sensor provided on a line, through which the first refrigerant is discharged from the rear door cooling unit to the refrigerant distribution unit, among the first refrigerant circulation lines, to measure discharge temperature of the first refrigerant;

a pressure sensor provided on the line, through which the first refrigerant is discharged from the rear door cooling unit to the refrigerant distribution unit, among the first refrigerant circulation lines, to measure discharge pressure of the first refrigerant; and

a refrigerant flow rate adjustment valve provided on a line, through which the first refrigerant is discharged from the rear door cooling unit to the refrigerant distribution unit, among the first refrigerant circulation lines, to selectively adjust opening on a discharge side of the first refrigerant circulation line.

5. The server rack cooling system of the data center of claim 4, wherein the rear door cooling unit performs an operation including:

a step of opening the refrigerant flow rate adjustment valve while a fan of the blower is in operation to circulate the first refrigerant to the first heat exchanger along the first refrigerant circulation line;

a step of measuring discharge temperature and discharge pressure of the first refrigerant circulating from the rear door cooling unit to the refrigerant distribution unit;

a step of measuring inflow air dry bulb temperature wherein the inflow air is server discharge air flowing into the first heat exchanger and measuring exhaust air dry bulb temperature wherein the exhaust air is the server discharge air passing through the first heat exchanger;

a step of gradually decreasing an operation rate of the fan of the blower when a difference between the measured inflow air dry bulb temperature and the exhaust air dry bulb temperature is less than set temperature;

a step of gradually increasing the operation rate of the fan of the blower when the difference between the measured inflow air dry bulb temperature and the exhaust air dry bulb temperature is greater than the set temperature;

a step of maintaining the operation rate of the fan of the blower when the difference between the measured inflow air dry bulb temperature and the exhaust air dry bulb temperature is equal to the set temperature;

a step of calculating a superheat degree of the first refrigerant by using the measured discharge temperature of the first refrigerant and the measured discharge pressure of the first refrigerant;

a step of gradually decreasing an opening rate of the refrigerant flow rate adjustment valve when the calculated superheat degree is less than the set superheat degree;

a step of gradually increasing the opening rate of the refrigerant flow rate adjustment valve when the calculated superheat degree is greater than the set superheat degree; and

a step of maintaining the opening rate of the refrigerant flow rate adjustment valve when the calculated superheat degree is equal to the set superheat degree.

6. The server rack cooling system of the data center of claim 4, wherein the refrigerant distribution unit includes:

a first plate-shaped heat exchanger connecting the first refrigerant circulation line through which the first refrigerant circulates to the cold water circulation line through which

the cold water circulates, and configured to cool and condense the first refrigerant through heat exchange with the cold water;

a first reservoir tank connected to the first plate-shaped heat exchanger by the first refrigerant circulation line through which the first refrigerant circulates, receiving and accommodating the first refrigerant cooled and condensed by the first plate-shaped heat exchanger, configured to separate a gaseous first refrigerant from a liquid first refrigerant, and configured to discharge the liquid first refrigerant; and

a first refrigerant pump connected to the first reservoir tank by the first refrigerant circulation line through which the first refrigerant flows, configured to pump the liquid first refrigerant discharged from the first reservoir tank, and configured to transfer the liquid first refrigerant to the rear door cooling unit.

7. The server rack cooling system of the data center of claim 6, wherein the refrigerant distribution unit performs an operation including:

a step of operating the first refrigerant pump to circulate the first refrigerant along the first refrigerant circulation line;

a step of measuring discharge temperature and discharge pressure of the first refrigerant circulating along the first refrigerant circulation line;

a step of calculating a cold water side cooling load;

a step of gradually increasing an opening rate of an energy valve when the calculated cold water side cooling load is less than a set cold water side cooling load;

a step of gradually decreasing the opening rate of the energy valve when the calculated cold water side cooling load is greater than the set cold water side cooling load;

a step of maintaining the opening rate of the energy valve when the calculated cold water side cooling load is equal to the set cold water side cooling load;

a step of calculating a subcooling degree of the first refrigerant by using the measured discharge temperature of the first refrigerant and the measured discharge pressure of the first refrigerant;

a step of gradually decreasing an operation rate of the first refrigerant pump when the calculated subcooling degree is less than a set subcooling degree;

a step of gradually increasing the operation rate of the first refrigerant pump when the calculated subcooling degree is greater than the set subcooling degree; and

a step of maintaining the operation rate of the first refrigerant pump when the calculated subcooling degree is equal to the set subcooling degree.

8. The server rack cooling system of the data center of claim 6, wherein the dual refrigerant distribution units perform a recovery operation including:

a step of starting a heartbeat communication with each refrigerant distribution unit when the dual refrigerant distribution unit starts to operate, and checking whether a normal communication is performed;

a step of maintaining a closed state of the solenoid valve when the heartbeat communication is performed normally; and

a step of opening the solenoid valve on a side where the normal communication is performed when any one of the dual refrigerant distribution units fails to perform the normal communication during the heartbeat communication of the dual refrigerant distribution units, to circulate the first refrigerant to the rear door cooling unit on a side where the normal communication is not performed.

9. The server rack cooling system of the data center of claim 4, wherein the free cooling refrigeration unit includes:

a free cooling portion configured to cool the cold water through heat exchange with a second refrigerant cooled by outside air;

a refrigeration unit connected to the free cooling portion and configured to cool the cold water through heat exchange with a third refrigerant that repeats evaporation, compression, condensation, and expansion processes;

a cold water tank connected to the refrigeration portion by the cold water circulation line through which the cold water circulates and receiving and accommodating the cold water cooled by the refrigeration portion; and

a water pump connected to the cold water tank by the cold water circulation line through which the cold water circulates, and configured to transfer the cold water accommodated in the cold water tank to the refrigerant distribution unit.

10. The server rack cooling system of the data center of claim 9, wherein the free cooling portion includes:

a second plate-shaped heat exchanger connecting the cold water circulation line through which the cold water circulates to a second refrigerant circulation line through which a second refrigerant circulates, and configured to cool the cold water through heat exchange with the second refrigerant;

a second heat exchanger connected to the second plate-shaped heat exchanger by the second refrigerant circulation line through which the second refrigerant circulates, receiving the second refrigerant heat-exchanged with the cold water, and configured to cool the received second refrigerant through heat exchange with the outside air;

a second reservoir tank connected to the second heat exchanger by the second refrigerant circulation line through which the second refrigerant circulates and receiving and accommodating the second refrigerant cooled by the second heat exchanger; and

a second refrigerant pump connected to the second reservoir tank by the second refrigerant circulation line through which the second refrigerant circulates and transferring the second refrigerant accommodated in the second reservoir tank to the second plate-shaped heat exchanger.

11. The server rack cooling system of the data center of claim 10, wherein the refrigeration portion includes:

a third plate-shaped heat exchanger connected to the cold water circulation line through which the cold water circulates and a third refrigerant circulation line through which a third refrigerant circulates and configured to cool the cold water through heat exchange with the third refrigerant;

an accumulator connected to the third plate-shaped heat exchanger by the third refrigerant circulation line through which the third refrigerant circulates, receiving the third refrigerant discharged from the third plate-shaped heat exchanger, configured to separate the third refrigerant into a liquid third refrigerant and a gaseous third refrigerant, and configured to discharge the gaseous third refrigerant to a compressor;

the compressor connected to the accumulator by the third refrigerant circulation line through which the third refrigerant circulates, configured to compress the gaseous third refrigerant discharged from the accumulator, and configured to discharge the third refrigerant with high temperature and high pressure;

an oil separator connected to the compressor by the third refrigerant circulation line through which the third refrigerant circulates, configured to remove oil from the third refrigerant discharged from the compressor, and configured to discharge the third refrigerant from which the oil is removed;

a condenser connected to the oil separator by the third refrigerant circulation line through which the third refrigerant circulates, configured to condense the third refrigerant, which is discharged from the oil separator, through heat exchange with the outside air, and configured to discharge the condensed third refrigerant;

a third reservoir tank connected to the condenser by the third refrigerant circulation line through which the third refrigerant circulates and receiving and accommodating the third refrigerant condensed by the condenser;

a strainer connected to the third reservoir tank by the third refrigerant circulation line through which the third refrigerant circulates and configured to remove foreign substances included in the third refrigerant discharged from the third reservoir tank; and

an electronic expansion valve connected to the strainer by the third refrigerant circulation line through which the third refrigerant circulates, receiving the third refrigerant passing through the strainer, configured to expand the third refrigerant, and configured to discharge the expanded third refrigerant to the third plate-shaped heat exchanger.

12. The server rack cooling system of the data center of claim 11, wherein the free cooling refrigeration unit performs an operation including:

a step of operating only the refrigeration portion in a cooling mode;

a step of receiving a compressor inverter operation value of the refrigeration portion;

a step of comparing the received compressor inverter operation value with a set dual conversion compressor inverter operation value and maintaining the cooling mode

when the compressor inverter operation value is greater than the set dual conversion compressor inverter operation value;

a step of comparing the received compressor inverter operation value with the set dual conversion compressor inverter operation value and converting into a dual mode when the compressor inverter operation value is less than the set dual conversion compressor inverter operation value;

a step of operating both the refrigeration portion and the free cooling portion in a dual mode;

a step of comparing the received compressor inverter operation value with a set free cooling conversion compressor inverter operation value and maintaining the cooling mode when the compressor inverter operation value of the refrigeration portion is greater than the set free cooling conversion compressor inverter operation value;

a step of comparing the received compressor inverter operation value with the set free cooling conversion compressor inverter operation value and converting into a free cooling mode when the compressor inverter operation value is less than the set free cooling conversion compressor inverter operation value;

a step of operating only the free cooling portion in the free cooling mode;

a step of measuring inflow temperature of the cold water circulating to the refrigerant distribution unit and discharge temperature of the cold water;

a step of converting back to the dual mode when a difference between the measured inflow temperature of the cold water and the measured discharge temperature of the cold water is less than a set minimum cold water temperature; and

a step of maintaining the free cooling mode when the difference between the measured inflow temperature of the cold water and the measured discharge temperature of the cold water is less than the set minimum cold water temperature.