

REFRIGERANT CIRCULATION APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a refrigerant circulation apparatus, and
5 particularly to a refrigerant circulation apparatus for controlling a cooling capacity at the time of failure of a cooling unit blower in an air-conditioning system.

Description of the Related Art

In a server room, a large number of electronic devices such as a computer and a server are placed in a concentrated state. Electronic devices are generally placed by a
10 rack mount method, that is, a method of stacking racks (casings), which house the electronic devices with the electronic devices separated according to functional units, on cabinets in layer, and a large number of cabinets are disposed in line on the floor of a server room.

These electronic devices need a constant temperature environment for
15 performing a normal operation, and if the electronic devices are brought into a high-temperature state, a trouble such as system stoppage is likely to be caused. Therefore, a server room is controlled to be under a constant temperature environment by a year-round cooling type package air-conditioner or the like. However, if the air-conditioner fails, the inside of the room is brought into a high-temperature state by the generated
20 heat of the devices, and the room is brought into a state where high-temperature spots locally occur. The allowable temperature of electronic devices is generally about a room temperature. Thus, if the ambient air has a high temperature, the devices themselves are likely to stop automatically by protection control to be incapable of continuing operation, and further, the components of the devices are likely to be broken
25 and fail.

Japanese Patent Application Laid-Open No. 2009-047419 discloses a refrigerant circulation apparatus which is equipped with the countermeasures against the occasion of failure of an air-conditioner. The refrigerant circulation apparatus of
Japanese Patent Application Laid-Open No. 2009-047419 is provided with an indoor
30 unit, an outdoor unit, a compressor, an expansion valve and refrigerant piping which

connects these components, and, for example, when the compressor fails, after confirming that the indoor unit blower is operable, if the maximum temperature calculated based on the measured value of the temperature sensor placed indoor exceeds the upper limit temperature which is set based on the allowable temperature of the electronic devices, operation of the blower is continued.

SUMMARY OF THE INVENTION

However, since the refrigerant circulation apparatus of Japanese Patent Application Laid-Open No. 2009-047419 cannot perform cooling operation when the compressor fails, there arises the fear that cooling performance is reduced, which leads to temperature rise in the room and causes failure of the electronic devices. Further, when the blower fails, any measures cannot be taken.

The present invention is made in view of the above circumstances, and has an object to provide, in a refrigerant circulation apparatus for an air-conditioning system which naturally circulates a refrigerant, a refrigerant circulation apparatus which can increase a cooling capacity and compensate the capacity even when at least one of a plurality of blowers which blow air to an evaporator fails, air flow quantity decreases, and the cooling capacity reduces.

In order to attain the above-described object, an aspect of the present invention provides, a refrigerant circulation apparatus including: an evaporator configured to evaporate a refrigerant; a blowing device configured to blow air to the evaporator; a condenser configured to condense the refrigerant evaporated by the evaporator; a refrigerant liquid pipe and a refrigerant gas pipe which connect the evaporator and the condenser; a blower failure detecting device configured to detect failure of the blowing device; a heat medium flow rate control valve configured to control a flow rate of a heat medium supplied to the condenser, the heat medium for cooling the refrigerant; a condenser refrigerant liquid temperature sensor configured to detect a temperature of the refrigerant which is supplied to the evaporator from the condenser; and a condenser side refrigerant temperature control device configured to lower a setting temperature of a condenser side externally inputted temperature and control the heat medium flow rate control valve so that a measured value measured by the condenser refrigerant liquid temperature sensor becomes equal to the lowered setting temperature, when receiving a failure signal from the blower failure detecting device.

In order to solve the aforementioned problem, the refrigerant circulation apparatus according to the aspect of the present invention increases the cooling capacity by lowering the condensing temperature.

5 The refrigerant circulation apparatus according to the present invention, that is, the refrigerant circulation apparatus which naturally circulates a refrigerant, is configured by connecting the condenser which is placed at a place higher than the evaporator with gas piping and liquid piping. The gas of the refrigerant which is vaporized by the evaporator is fed to the condenser via the gas piping, and the liquid of the refrigerant which is liquefied by the condenser is fed to the evaporator through the
10 liquid piping, whereby the refrigerant is naturally circulated, and the cooling action can be obtained in the evaporator. Such a refrigerant natural circulation type air-conditioning system is applied to local cooling for a server, and thereby, the running cost of the air conditioner can be reduced.

The refrigerant circulation apparatus according to the aspect of the present
15 invention preferably further includes a condenser side control temperature calculating device configured to calculate a necessary condenser side control temperature based on a number of failed blowers and a cooling performance table which is set in advance when the failure signal is outputted from the blower failure detecting device, wherein: the blowing device includes a plurality of blowers; and the condenser side refrigerant
20 temperature control device lowers the setting temperature of the condenser side externally inputted temperature to the calculated necessary condenser side control temperature and controls the heat medium flow rate control valve so that the measured value measured by the condenser refrigerant temperature sensor becomes equal to the lowered setting temperature.

25 Thus, the refrigerant circulation apparatus according to the present invention can calculate a necessary condensing temperature from the number of failed blowers and the cooling performance table, reduce the condensing temperature to that condensing temperature, and thereby, increase the cooling capacity.

The refrigerant circulation apparatus according to the aspect of the present
30 invention preferably further includes an evaporator internal pressure sensor configured to measure an internal pressure in the evaporator, wherein: when the failure signal is outputted from the blower failure detecting device, the condenser side control temperature calculating device calculates a necessary condenser side control

temperature based on the number of failed blowers, the measured value of the evaporator internal pressure sensor and the cooling performance table which is set in advance; and the condenser side refrigerant temperature control device lowers the setting temperature of the condenser side externally inputted temperature to the
5 calculated necessary condenser side control temperature and controls the heat medium flow rate control valve so that the measured value measured by the condenser refrigerant liquid temperature sensor becomes equal to the lowered setting temperature.

Thus, the refrigerant circulation apparatus according to the present invention can calculate the necessary condensing temperature based on the number of failed
10 blowers, the measured value of the evaporator internal pressure sensor and the cooling performance table, and lower the condensing temperature to that condensing temperature, and thereby, increase the cooling capacity. By actually measuring the evaporation temperature with the evaporator internal pressure sensor, the condensing temperature can be more accurately set to the condensing temperature for achieving
15 necessary cooling capacity. Thereby, loss of the heat quantity is prevented.

The refrigerant circulation apparatus according to the aspect of the present invention preferably further includes an indoor dew-point temperature sensor configured to detect an indoor dew-point temperature, wherein: when the failure signal is outputted from the blower failure detecting device, the condenser side control
20 temperature calculating device calculates a necessary condenser side control temperature based on the number of failed blowers and the cooling performance table which is set in advance; and the condenser side refrigerant temperature control device updates the setting temperature of the condenser side externally inputted temperature to the calculated necessary condenser side control temperature when the calculated
25 necessary condenser side control temperature is not less than an indoor dew-point temperature, or the condenser side refrigerant temperature control device lowers the setting temperature to the indoor dew-point temperature and controls the heat medium flow rate control valve so that measured value measured by the condenser refrigerant liquid temperature sensor becomes equal to the lowered setting temperature when the
30 calculated necessary condenser side control temperature is not more than the indoor dew-point temperature.

The present invention adds measure for prevent dew formation in a room.

According to the refrigerant circulation apparatus of the present invention, when at least one of the blowers which blow air to the evaporator fails, the cooling capacity is increased by lowering the condensing temperature, and therefore, the cooling unit capacity can be compensated. Further, in addition to this, dew formation
5 in the evaporator can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing a configuration of a refrigerant circulation apparatus of a first embodiment;

Fig. 2 is a block diagram showing a configuration of a refrigerant circulation
10 apparatus of a second embodiment;

Fig. 3 is a block diagram showing a configuration of a refrigerant circulation apparatus of a third embodiment;

Fig. 4 is a block diagram showing a configuration of a refrigerant circulation apparatus of a fourth embodiment;

15 Fig. 5 is a block diagram showing a configuration of a refrigerant circulation apparatus of a fifth embodiment;

Fig. 6 is a block diagram showing a configuration of a refrigerant circulation apparatus of a sixth embodiment; and

Fig. 7 is a block diagram showing a configuration of a refrigerant circulation
20 apparatus of a seventh embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, preferred embodiments of a refrigerant apparatus according to the present invention will be described in accordance with the accompanying drawings.

Fig. 1 is a block diagram showing a configuration of a refrigerant circulation
25 apparatus of a first embodiment.

In Fig. 1, a condenser 3 is a device for cooling and condensing a refrigerant which is vaporized in two evaporators 1 and 1. The number of evaporators 1 is not limited to two.

The condenser 3 is provided at a place higher than the evaporator 1, for
30 example, on the roof of a building. The condenser 3 is internally provided with a coil in which a heat medium (for example, cold water) which cools the refrigerant so that the

vaporized refrigerant performs heat exchange and the refrigerant is liquefied. The heat medium which cools the aforesaid refrigerant in the condenser 3 is supplied from a heat medium creating device 21 (for example, a refrigerator) by using a heat medium conveying device 22.

5 The evaporators 1 and 1 and the condenser 3 are connected through a refrigerant liquid pipe 4 and a refrigerant gas pipe 5. An upper end of the refrigerant gas pipe 5 is connected to one end of the coil in the condenser 3, and a lower end of the refrigerant gas pipe 5 is connected to one end of a coil of each evaporator 1. Meanwhile, an upper end of the refrigerant liquid pipe 4 is connected to the other end of the coil in the condenser 3, and a lower end of the refrigerant liquid pipe 4 is connected to the other end of the coil of the evaporator 1. Accordingly, a gas of the refrigerant which is vaporized by each of the evaporators 1 and 1 is naturally fed to the condenser 3 through the refrigerant gas pipe 5, and after the gas is liquefied by the condenser 3, the liquefied refrigerant is naturally flows down to each evaporator 1 through the refrigerant liquid pipe 4. Thereby, natural circulation of the refrigerant is performed.

As the refrigerant which circulates, chlorofluorocarbons, or HFC (hydrochlorofluorocarbon) as alternative chlorofluorocarbons or the like can be used. Further, if used at a pressure lower than atmospheric pressure, water can be used.

A cooling unit which includes the evaporators 1 and blowers 2 (in Fig. 1, two blowers 2 are shown, as an example) which blow air to the evaporators 1, is provided at a rear surface of a server rack 24, and exhaust heat from the electronic devices housed in the server rack 24 is performed by blowing air to the evaporators 1 by the blowers 2. Thereby, air warmed by the electronic devices is cooled and is released into the inside of the server room. The blowers 2 are provided with a blower failure detecting device 6 which detects failure of the blowers 2.

The refrigerant circulation apparatus is provided with a condenser side refrigerant temperature control device 7 for controlling the temperature of the refrigerant which is supplied to the condenser 3. The condenser side refrigerant temperature control device 7 controls an opening degree of a heat medium flow rate control valve 23 provided at heat medium piping 25 so that a measured value of a condenser refrigerant liquid temperature sensor 8 provided at the refrigerant liquid pipe 4 at an outlet port of the condenser 3 becomes equal to a setting temperature of the condenser side externally inputted temperature.

Further, upon receiving a failure signal from the blower failure detecting device 6, the condenser side refrigerant temperature control device 7 lowers the setting temperature of the condenser side externally inputted temperature, and controls the opening degree of the heat medium flow rate control valve 23 so that the measured value of the condenser refrigerant liquid temperature sensor 8 becomes equal to the setting temperature.

Thereby, according to the refrigerant circulation apparatus of the first embodiment, the condensing temperature is reduced and the cooling capacity can be increased, whereby the capacity of the cooling unit can be compensated.

Fig. 2 is a block diagram showing a configuration of a refrigerant circulation apparatus of a second embodiment. The same or similar members as those in the refrigerant circulation apparatus shown in Fig. 1 will be described by being assigned with the same reference numerals.

The refrigerant circulation apparatus of Fig. 2 is further provided with a condenser side control temperature calculating device 9 which calculates a control temperature of the condenser 3, when comparing the refrigerant circulation apparatus shown in Fig. 1.

When a failure signal is inputted to the condenser side refrigerant temperature control device 7 from the blower failure detecting device 6, the evaporation temperature needs to be lowered to discharge the heat quantity corresponding to the reduction in an air quantity. In the refrigerant natural circulation system of the refrigerant circulation apparatus, the evaporation temperature varies with the condensing temperature. In this case, the condensing temperature is lowered.

In order to lower the evaporation temperature by the evaporation temperature corresponding to reduction in the air quantity, the condenser side control temperature calculating device 9 calculates a necessary condenser side control temperature (calculated value) from a number of failed blowers 2 and the cooling performance table which is set in advance. Subsequently, the condenser side refrigerant temperature control device 7 reduces the setting temperature of the condenser side externally inputted temperature to the calculated value, and controls the opening degree of the heat medium flow rate control valve 23 so that the measured value of the condenser refrigerant liquid temperature sensor 8 becomes equal to the setting temperature.

Thereby, according to the refrigerant circulation apparatus of the second embodiment, the condensing temperature is lowered and the cooling capacity can be increased, whereby the cooling unit capacity can be compensated.

Calculation of the condenser side control temperature is performed by setting the relational expression of the air quantity and the cooling capacity, the relational expression of the cooling capacity and the evaporation temperature, the design conditions, the relational expression of the evaporation temperature and the condensing temperature, and the relational expression of the condensing temperature and the condenser refrigerant liquid temperature, in the cooling performance table in advance.

Fig. 3 is a block diagram showing a configuration of a refrigerant circulation apparatus of a third embodiment, and the same or similar members as those of the refrigerant circulation apparatus shown in Fig. 1 will be described by being assigned with the same reference numerals.

A refrigerant circulation apparatus of Fig. 3 is further provided with an evaporator internal pressure sensor 11 which detects a pressure inside the evaporator 1 when comparing the refrigerant circulation apparatus shown in Fig. 2.

When a failure signal is inputted to the condenser side refrigerant temperature control device 7 from the blower failure detecting device 6, the evaporation temperature needs to be lowered to discharge the heat quantity corresponding to reduction in an air quantity. In the refrigerant natural circulation system of the refrigerant circulation apparatus, the evaporation temperature varies with the condensing temperature. In this case, the condensing temperature is lowered.

In order to achieve the evaporation temperature corresponding to the decreased air quantity, the condenser side control temperature calculating device 9 calculates the evaporation temperature from the measured value of the evaporator internal pressure sensor 11 set in advance, calculates a degree of temperature by which the evaporation temperature should be lowered, and calculates by a degree of temperature (calculation value) by which the condensing temperature should be lowered from the relational expression of the evaporation temperature and the condensing temperature. In order to achieve the condensing temperature, the condensing side refrigerant temperature control device 7 calculates the condenser side externally inputted temperature from the relational expression of the condensing temperature and the condenser refrigerant liquid temperature, lowers the setting temperature of the condenser side externally inputted

temperature to the calculated value, and controls the opening degree of the heat medium flow rate control valve 23 so that the measured value of the condenser refrigerant liquid temperature sensor 8 becomes equal to the setting temperature.

Thereby, according to the refrigerant circulation apparatus of the third
 5 embodiment, the cooling capacity can be increased while the condensing temperature is more accurately set to the condensing temperature for achieving a necessary cooling capacity, and therefore, the cooling unit capacity can be compensated.

Calculation of the condenser side control temperature is performed in the condenser side control temperature calculating device 9 by setting the relational
 10 expression of the air quantity and the cooling capacity, the relational expression of the cooling capacity and the evaporation temperature, the design conditions, the relational expression of the evaporation temperature and the condensing temperature, and the relational expression of the condensing temperature and the condenser refrigerant liquid temperature in the cooling performance table in advance.

15 Fig. 4 is a block diagram showing a configuration of a refrigerant circulation apparatus of a fourth embodiment, and the same or similar members as those of the refrigerant circulation apparatus shown in Fig. 1 will be described by being assigned with the same reference numerals.

The refrigerant circulation apparatus of Fig. 4 is further provided with an
 20 indoor dew-point temperature sensor 10 which detects an indoor dew-point temperature when comparing the refrigerant circulation apparatus shown in Fig. 2.

When a failure signal is inputted to the condenser side refrigerant temperature control device 7 from the blower failure detecting device 6, the evaporation temperature needs to be lowered to discharge the heat quantity corresponding to reduction in an air
 25 quantity. In the refrigerant natural circulation system of the refrigerant circulation apparatus, the evaporation temperature varies with the condensing temperature. In this case, the condensing temperature is lowered.

In order to lower the evaporation temperature by a degree of temperature corresponding to reduction in an air quantity, the condenser side control temperature
 30 calculating device 9 calculates the necessary condenser side control temperature (calculated value) from the cooling performance table which is set in advance. The condenser side refrigerant temperature control device 7 resets (update) the setting temperature of the condenser side externally inputted temperature to the calculated

value when the calculated value is not less than the measured value of the indoor dew-point temperature sensor 10. On the other hand, the condenser side refrigerant temperature control device 7 lowers the setting temperature to the measured value of the indoor dew-point temperature sensor 10 when the calculated value is not more than the measured value of the indoor dew-point temperature sensor 10, and controls the opening degree of the heat medium flow rate control valve 23 so that the measured value of the condenser refrigerant liquid temperature sensor 8 becomes equal to the setting temperature.

Thereby, according to the refrigerant circulation apparatus of the fourth embodiment, the cooling unit capacity is increased by increasing the cooling capacity by lowering the condensing temperature, and dew formation in the evaporator 1 can be prevented.

The calculation of the condenser side control temperature is performed by setting the relational expression of the air quantity and the cooling capacity, the relational expression of the cooling capacity and the evaporation temperature, the design conditions, the relational expression of the evaporation temperature and the condensing temperature, and the relational expression of the condensing temperature and the condenser refrigerant liquid temperature in the cooling performance table, in advance.

Fig. 5 is a block diagram showing a configuration of a refrigerant circulation apparatus of a fifth embodiment, and the same or similar members as those of the refrigerant circulation apparatus shown in Fig. 1 will be described by being assigned with the same reference numerals. The refrigerant circulation apparatus of Fig. 5 is an apparatus which controls the frequency of the heat medium conveying device 22 by a heat medium conveying device controlling device 26 instead of controlling the opening degree of the heat medium flow rate control valve 23 in the refrigerant circulation apparatus shown in Fig. 1. The same thing applies to the refrigerant circulation apparatuses shown in Figs. 2 to 4.

Fig. 6 is a block diagram showing a configuration of a refrigerant circulation apparatus of a sixth embodiment, and the same or similar members as those of the refrigerant circulation apparatus shown in Fig. 1 will be described by being assigned with the same reference numerals. The refrigerant circulation apparatus of Fig. 6 is an apparatus which controls the frequency of a water spray type air-cooled condenser 27

by a water spray type air-cooled condenser blower control device 29 instead of controlling the opening degree of the heat medium flow rate control valve 23 when the condenser 3 is a water spray type air-cooled condenser 27 in the refrigerant circulation apparatus shown in Fig. 1. The same thing applies to the refrigerant circulation apparatuses shown in Figs. 2 to 4.

Fig. 7 is a block diagram showing a configuration of a refrigerant circulation apparatus of a seventh embodiment, and the same or similar members as those of the refrigerant circulation apparatus shown in Fig. 1 will be described by being assigned with the same reference numerals. The refrigerant circulation apparatus of Fig. 7 is an apparatus which controls the frequency of a water spraying circulation pump 30 by a water spraying circulation pump control device 31 instead of controlling the frequency of the water spray type air-cooled condenser blower control device 29 in the refrigerant circulation apparatus shown in Fig. 6.

WHAT IS CLAIMED IS:

1. A refrigerant circulation apparatus comprising:
 - an evaporator configured to evaporate a refrigerant;
 - a blowing device configured to blow air to the evaporator;
 - a condenser configured to condense the refrigerant evaporated by the evaporator;
 - a refrigerant liquid pipe and a refrigerant gas pipe which connect the evaporator and the condenser;
 - a blower failure detecting device configured to detect failure of the blowing device;
 - a heat medium flow rate control valve configured to control a flow rate of a heat medium supplied to the condenser, the heat medium for cooling the refrigerant;
 - a condenser refrigerant liquid temperature sensor configured to detect a temperature of the refrigerant which is supplied to the evaporator from the condenser;
 - a condenser side refrigerant temperature control device configured to lower a setting temperature of a condenser side externally inputted temperature and control the heat medium flow rate control valve so that a measured value measured by the condenser refrigerant liquid temperature sensor becomes equal to the lowered setting temperature, when receiving a failure signal from the blower failure detecting device; and
 - a condenser side control temperature calculating device configured to calculate a necessary condenser side control temperature based on a number of failed blowers and a cooling performance table which is set in advance when the failure signal is outputted from the blower failure detecting device, wherein:
 - the blowing device includes a plurality of blowers; and
 - the condenser side refrigerant temperature control device lowers the setting temperature of the condenser side externally inputted temperature to the calculated necessary condenser side control temperature and controls the heat medium flow rate control valve so that the measured value measured by the condenser refrigerant temperature sensor becomes equal to the lowered setting temperature.

2. The refrigerant circulation apparatus according to claim 1, further comprising an evaporator internal pressure sensor configured to measure an internal pressure in the evaporator, wherein:

when the failure signal is outputted from the blower failure detecting device, the condenser side control temperature calculating device calculates a necessary condenser side control temperature based on the number of failed blowers, the measured value of the evaporator internal pressure sensor and the cooling performance table which is set in advance; and

the condenser side refrigerant temperature control device lowers the setting temperature of the condenser side externally inputted temperature to the calculated necessary condenser side control temperature and controls the heat medium flow rate control valve so that the measured value measured by the condenser refrigerant liquid temperature sensor becomes equal to the lowered setting temperature.

3. The refrigerant circulation apparatus according to claim 1 or 2, further comprising an indoor dew-point temperature sensor configured to detect an indoor dew-point temperature, wherein:

when the failure signal is outputted from the blower failure detecting device, the condenser side control temperature calculating device calculates a necessary condenser side control temperature based on the number of failed blowers and the cooling performance table which is set in advance; and

the condenser side refrigerant temperature control device updates the setting temperature of the condenser side externally inputted temperature to the calculated necessary condenser side control temperature when the calculated necessary condenser side control temperature is not less than an indoor dew-point temperature, or

the condenser side refrigerant temperature control device lowers the setting temperature to the indoor dew-point temperature and controls the heat medium flow rate control valve so that measured value measured by the condenser refrigerant liquid temperature sensor becomes equal to the lowered setting temperature when the calculated necessary condenser side control temperature is not more than the indoor dew-point temperature.