

DESCRIPTION

TITLE OF THE INVENTION :

COOLING SYSTEM AND METHOD FOR OPERATING SAME

TECHNICAL FIELD

5 [0001]

The present invention relates to an air conditioning system of the type that makes a refrigerant pump circulate a refrigerant desired for an air conditioning device disposed in a room to be air-conditioned and a method of
10 operating the air conditioning system.

BACKGROUND ART

[0002]

A refrigerant forced circulation type cooling system that performs cooling by exchanging heat between cold
15 water prepared on the primary side and a refrigerant and then circulating the heat-exchanged refrigerant by a refrigerant pump on the secondary side has been adopted so far in order to increase heat transport efficiency by latent heat transport or as a countermeasure taken in an
20 application where circulation of cold water in a room to be air-conditioned is not desirable. In a cooling system of the type as mentioned above, the cooling capacity is controlled by changing the operation state of the refrigerant pump or the quantity of cold water supplied
25 thereto with load fluctuation. However, when the balance

between the pressure in a refrigerant circulation system and the temperature of the refrigerant is lost in controlling the cooling capacity, cavitation may occur on the suction side of the refrigerant pump and the performance of the refrigerant pump may be suddenly degraded.

[0003]

Under the circumstances as mentioned above, various techniques of preventing occurrence of cavitation in a refrigerant pump in a refrigerant forced circulation type cooling system are proposed. In a controlling technique of preventing occurrence of cavitation in a cooling system disclosed, for example, in Patent Document 1, occurrence of cavitation is prevented by making a pressure reducing speed different from a temperature reducing speed in a refrigerant circulation system by stepwise increasing the quantity of cold water supplied thereto when a load exerted onto the system is increased and hence the quantity of cold water supplied thereto is to be increased.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: Japanese Patent Application Laid-Open No. 2008-281218

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005]

However, in the system of preventing occurrence of cavitation by stepwise adjusting a speed at which the quantity of cold water supplied thereto is increased which is disclosed in the Patent Document 1, since the temperature of a refrigerant liquid in a condenser 6a is lowered with cold water so as to cope with load fluctuation as illustrated in FIG. 7, the pressure of the refrigerant in the condenser 6a may be reduced to cause a reduction in evaporating temperature of an evaporator 7a in a room to be air-conditioned. When the evaporating temperature of the evaporator 7a is reduced, the inside of the room to be air-conditioned may be excessively cooled and may not be appropriately air-conditioned and energy-saving operation may not be attained. Therefore, it becomes important to control the pressure in the system when the room to be air-conditioned is excessively cooled in order to appropriately control the air-conditioning capacity.

[0006]

In view of the above mentioned problem of related art, the present invention aims to provide an air conditioning system that prevents occurrence of cavitation in a refrigerant pump and attains appropriate control of

the air conditioning capacity and a method of operating the air conditioning system.

MEANS FOR SOLVING THE PROBLEMS

[0007]

5 In order to solve the above mentioned problem, the present invention provides an air conditioning system that includes an evaporator for vaporizing a refrigerant by exchanging heat between the refrigerant and air in a room to be air-conditioned, a condenser for liquefying a
10 refrigerant gas vaporized by the evaporator, a refrigerant pump for feeding a refrigerant liquid liquefied by the condenser to the evaporator, a refrigerant liquid tank disposed between the condenser and the refrigerant pump to temporarily store the refrigerant liquid liquefied by the
15 condenser and first cold water piping for supplying cold water generated from a heat source machine to the condenser, and further includes second cold water piping for supplying the cold water generated from the heat source machine to the refrigerant liquid tank, a
20 refrigerant liquid temperature sensor for measuring a temperature of the refrigerant liquid in the refrigerant liquid tank and a control unit for controlling to supply the cold water desired for condensation of the refrigerant gas to the condenser.

25 [0008]

In the air conditioning system, the first cold water piping is series-connected with the second cold water piping to flow the cold water from the heat source machine to the condenser and the refrigerant liquid tank in series.

5 [0009]

In the air conditioning system, the first cold water piping is connected with the second cold water piping such that the cold water flows from the heat source machine to the condenser via the refrigerant liquid tank.

10 [0010]

The air conditioning system further includes pressure sensors for measuring a discharge pressure and a suction pressure of the refrigerant pump and an inverter for changing an operating frequency of the refrigerant pump, wherein the operating frequency of the refrigerant pump is controlled by the control unit such that a differential pressure between the discharge pressure and the suction pressure has a set value.

[0011]

20 The air conditioning system further includes a zero point temperature detection unit for detecting a zero point temperature in the room to be air-conditioned and a condensate temperature sensor for measuring a temperature of the refrigerant liquid liquefied by the condenser,
25 wherein when the temperature of the refrigerant liquid in

the refrigerant liquid tank is lower than the zero point temperature detected by the zero point temperature detection unit, the flow rate of the cold water into the refrigerant liquid tank is adjusted such that the

5 temperature of the refrigerant liquid in the refrigerant liquid tank becomes higher than the zero point temperature in the room and the flow rate of the cold water into the condenser is adjusted such that the temperature of the liquefied refrigerant in the condenser becomes higher than
10 the temperature of the refrigerant liquid in the refrigerant liquid tank by the control unit.

[0012]

In the air conditioning system, an evaporating temperature is calculated from the suction pressure of the
15 refrigerant pump and the cold water is supplied to the refrigerant liquid tank such that the temperature of the refrigerant liquid in the refrigerant liquid tank becomes lower than the calculated evaporating temperature by the control unit.

20 [0013]

In order to solve the above mentioned problem, the present invention also provides a method of operating an air conditioning system that includes an evaporator for vaporizing a refrigerant by exchanging heat between the
25 refrigerant and air in a room to be air-conditioned, a

condenser for liquefying a refrigerant gas vaporized by the evaporator, a refrigerant pump for feeding a refrigerant liquid liquefied by the condenser to the evaporator, a refrigerant liquid tank disposed between the condenser and the refrigerant pump to temporarily store the refrigerant liquid liquefied by the condenser and cold water piping for supplying cold water generated from a heat source machine to the condenser and the refrigerant liquid tank, and controls the operations of the above components by a control unit, wherein cold water desired for condensation of the refrigerant is supplied to the condenser.

EFFECT OF THE INVENTION

[0014]

According to the present invention, prevention of occurrence of cavitation and energy-saving operation are promoted by appropriately controlling the air conditioning capacity of the system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

[Fig. 1] FIG. 1 is a block configuration diagram of an embodiment 1 of the present invention.

[Fig. 2] FIG. 2 is a block configuration diagram of an embodiment 2 of the present invention.

[Fig. 3] FIG. 3 is a block configuration diagram of an

embodiment 3 of the present invention.

[Fig. 4] FIG. 4 is a block configuration diagram of an embodiment 4 of the present invention.

[Fig. 5] FIG. 5 is a flowchart of an operation of

5 controlling the flow rate of cold water into a condenser according to an embodiment of the present invention.

[Fig. 6] FIG. 6 is a flowchart of an operation of

controlling the flow rate of cold water into a refrigerant liquid tank according to an embodiment of the present

10 invention.

[Fig. 7] FIG. 7 is a block configuration diagram of related art.

MODE FOR CARRYING OUT THE INVENTION

[0016]

15 Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings.

[0017]

(Embodiment 1)

20 FIG. 1 illustrates a block configuration diagram of an embodiment 1 of the present invention. An air

conditioning system includes evaporators 21a and 21b for vaporizing a refrigerant by exchanging heat between the refrigerant and air in a room to be air-conditioned, a

25 condenser 10 for liquefying a refrigerant gas vaporized by

the evaporators, a refrigerant pump 5 for circulating the refrigerant liquid liquefied by the condenser 10 to the evaporators 21a and 21b, a condensate temperature sensor 11 for measuring a temperature of the refrigerant liquid in the condenser 10, a refrigerant liquid tank 60 disposed between the condenser 10 and the refrigerant pump 50 to temporarily store the refrigerant liquid liquefied by the condenser 10, first cold water piping 71a for supplying cold water generated from a heat source machine 70 to the condenser 10 by a cold water pump 72 and the like.

[0018]

The air conditioning system also includes a refrigerant cooling mechanism 62 for cooling the refrigerant liquid in the refrigerant liquid tank 60, second cold water piping 71b for supplying the cold water generated from the heat source machine 70 to the refrigerant cooling mechanism 62, a refrigerant liquid temperature sensor 61 for measuring a temperature of the refrigerant liquid in the refrigerant liquid tank 60, and a control unit 74 for controlling to supply cold water of a quantity desired for condensation of the refrigerant to the condenser 10 by the cold water pump 72 and to supply a predetermined quantity of cold water to the refrigerant liquid tank 60 such that the temperature of the refrigerant liquid in the refrigerant liquid tank 60

becomes lower than an evaporating temperature corresponding to a suction pressure of the refrigerant pump 50.

[0019]

5 The evaporators 21a and 21b are respectively incorporated into cooling devices 20a and 20b together with fans 22a and 22b and are disposed in the room to be air-conditioned. The refrigerant liquid circulates in the evaporators 21a and 21b, and hot airs 23a and 23b in the
10 room are blown against the refrigerant liquid by the fans 22a and 22b to evaporate the refrigerant liquid in the devices to remove heat from the blown hot airs. As a result, the hot airs 23a and 23b in the room are cooled and are blown out into the room as cooled airs 24a and 24b.

15 [0020]

 On the other hand, a refrigerant gas gasified by being evaporated by the evaporators 21a and 21b is sent to the condenser 10 via a refrigerant gas pipe 30 and is liquefied by heat exchange performed between it and the
20 cold water from the heat source machine 70. The liquefied refrigerant is temporarily stored in the refrigerant tank 60 and is sent from within the tank 60 to the evaporators 21a and 21b by the refrigerant pump 50 via a refrigerant liquid pipe 31. In the above mentioned case, the flow
25 rate of the cold water is adjusted such that the

temperature of the refrigerant liquid in the condenser measured by the condensate temperature sensor 11 has a designed value desired for cooling in the cooling devices 20a and 20b. The adjustment is made by controlling the flow rate of the cold water in the cold water pump 72 by the control unit 74 or by controlling the flow rate by adjusting opening of a three-way valve 73 so as not to excessively reduce the temperature of the refrigerant liquid in the condenser.

10 [0021]

The above mentioned controlling operation is executed in accordance with an operation flow illustrated in FIG. 5. That is, after execution of the operation has been started in step (S) 101, a temperature of the condensate in the condenser 10 is measured by the sensor 11 in S102 and the temperature of the condensate is compared with a designed value desired for cooling by the cooling devices 20a and 20b so as to determine whether it is higher than the designed value in S103. When NO (lower) in S103, the quantity of cold water is controlled to be reduced in S105 and the operation returns to S102. When YES in S103, it is determined whether the condensate temperature is almost equal to the designed value in S104. When YES in S104, execution of the operation is terminated in S107. When NO (higher) in S104, the quantity of the

cold water is controlled to be increased in S106 and the operation returns to S102.

[0022]

The control unit 74 also controls to measure a
5 temperature of the refrigerant liquid in the refrigerant liquid tank 60 by the refrigerant liquid temperature sensor 61 and to calculate an evaporating temperature of a suction part of the refrigerant pump 50 from a suction side pressure value measured by a suction pressure sensor
10 51. Then, the control unit 74 controls to adjust the flow rate of the cold water flowing into the refrigerant liquid tank 60 such that the measured temperature of the refrigerant liquid in the tank is lower than the calculated evaporating temperature of the suction part of
15 the refrigerant pump 50 by 1 to 2°C. This controlling operation is executed in accordance with an operation flow illustrated in FIG. 6.

[0023]

After execution of the operation has been started in
20 step (S) 201, the temperature of the refrigerant liquid in the refrigerant liquid tank is measured and the evaporating temperature is calculated from the pressure value on the suction side of the refrigerant pump in S202. Then, it is determined whether the temperature of the
25 refrigerant liquid in the tank is lower than the

calculated evaporating temperature, for example, by about
2°C in S203. When YES in S203, execution of the operation
is terminated in S207. When NO in S203, it is determined
whether the temperature of the refrigerant liquid in the
5 tank is lower than the calculated evaporating temperature,
for example, by a value more than 2°C in S204. When YES
in S204, the quantity of cold water is controlled to be
reduced in S205 and the operation returns to S202. When
NO in S204, the quantity of the cold water is controlled
10 to be increased in S206 and the operation returns to S202.
[0024]

Since, the embodiment 1 is configured such that heat
exchange is shared by excessively cooling the refrigerant
liquid in the refrigerant liquid tank, liquefying the
15 refrigerant gas by the condenser and exchanging the
desired amount of heat by the cooling devices as described
above, it is allowed to suppress a reduction in pressure
of the refrigerant in the condenser 10. Thus, it is
allowed to suppress a reduction in pressure in the
20 refrigerant circulation system to prevent the inside of
the room to be air-conditioned from being excessively
cooled, thereby performing the appropriate operation. In
addition, it is allowed to prevent occurrence of
cavitation by controlling a relation between the
25 evaporating temperature on the suction side of the

refrigerant pump 50 and the temperature of the refrigerant liquid in the refrigerant liquid tank.

[0025]

(Embodiment 2)

5 FIG. 2 illustrates a block configuration diagram of an embodiment 2 of the present invention. The temperature of the refrigerant which has been excessively cooled in the refrigerant liquid tank 60 is controlled to be lower than the temperature of the refrigerant liquefied by the
10 condenser 10 as described in the embodiment 1. Therefore, the embodiment 2 is configured such that cold water of a temperature which is lower than the temperature of the cold water flowing into the condenser 10 flows into the refrigerant liquid tank 60 in order to facilitate the
15 controlling operation.

[0026]

Specifically, first cold water piping 71a and second cold water piping 71b for supplying cold water respectively to the condenser 10 and the refrigerant
20 liquid tank 60 are series-connected with each other. The cold water is cascade-used such that the cold water from the heat source machine 70 is first supplied to the refrigerant tank 60 to be heat-exchanged with the refrigerant liquid and the cold water which has been
25 increased in temperature by heat exchange is then supplied

to the condenser 10 to be heat-exchanged with the refrigerant gas so as to liquefy the refrigerant in the above mentioned connection. It is allowed to efficiently distribute heat to the refrigerant liquid tank 60 and the condenser 10 with cold water and to attain energy-saving operation of the heat source machine by cascade-using the cold water in the above mentioned manner.

[0027]

(Embodiment 3)

FIG. 3 illustrates a block configuration diagram of an embodiment 3 of the present invention. 51 denotes the refrigerant pump suction pressure sensor for measuring the suction pressure of the refrigerant pump 50, 52 denotes a refrigerant pump discharge pressure sensor for measuring a discharge pressure of the refrigerant pump 50, and 53 denotes an inverter for changing an operating frequency of the refrigerant pump 50. The control unit 74 controls the operating frequency of the inverter 53 such that a difference between a value measured by the suction pressure sensor 51 and a value measured by the discharge pressure sensor 52 has a set value. In the embodiment 3, since a differential pressure between the suction pressure and the discharge pressure of the refrigerant pump 50 is maintained at the set value, it is allowed to suppress an increase in evaporating pressure by suppressing an

increase in pressure in the refrigerant circulation system when a load is partially exerted on it and hence it is allowed to appropriately control the cooling capacity of the air conditioning system.

5 [0028]

(Embodiment 4)

FIG. 4 illustrates a block configuration diagram of an embodiment 4 of the present invention. In the embodiment 4, an in-room zero point temperature detection unit 80 for detecting a zero point temperature of a room to be air-conditioned 26 is installed. In the above mentioned configuration, when a value detected by the zero point temperature detection unit 80 is higher than a temperature of the refrigerant liquid in the refrigerant liquid tank 60, the control unit 74 controls to decrease the flow rate of cold water into the refrigerant liquid tank 60 such that the temperature of the refrigerant liquid in the refrigerant liquid tank 60 becomes higher than the in-room zero point temperature. The control unit 74 controls to decrease the flow rate of the cold water such that a temperature of the refrigerant at an outlet of the condenser 10 becomes higher than the set temperature of the refrigerant liquid in the refrigerant liquid tank 60 simultaneously.

25 [0029]

According to the embodiment 4, it is allowed to prevent generation of dew condensation by controlling the temperature of the refrigerant liquid in the refrigerant liquid tank 60 and the same effects as those attained by the above embodiments are obtained. That is, it is allowed to prevent occurrence of cavitation while suppressing an increase in pressure in the refrigerant circulation system and energy-saving operation is allowed by cascade-using the cold water.

10 DESCRIPTION OF REFERENCE NUMERALS OR SYMBOLS

[0030]

10: condenser, 11: condensate temperature sensor, 20a, 20b: cooling device, 21a, 21b: evaporator, 22a, 22b: fan, 26: room to be air-conditioned, 30: refrigerant gas pipe, 31: refrigerant liquid pipe, 50: refrigerant pump, 51: suction pressure sensor, 52: discharge pressure sensor, 53: inverter, 60: refrigerant liquid tank, 61: refrigerant liquid temperature sensor, 62: refrigerant cooling mechanism, 70: heat source machine, 71a: first cold water piping, 71b: second cold water piping, 72: cold water pump, 73: three-way valve, 74: control unit, 80: in-room zero point temperature detection unit.

CLAIMS

[Claim 1]

An air conditioning system comprising:

an evaporator for vaporizing a refrigerant by
5 exchanging heat between the refrigerant and air in a room
to be air-conditioned;

a condenser for liquefying a refrigerant gas
vaporized by the evaporator;

a refrigerant pump for feeding a refrigerant liquid
10 liquefied by the condenser to the evaporator;

a refrigerant liquid tank disposed between the
condenser and the refrigerant pump to temporarily store
the refrigerant liquid liquefied by the condenser; and

first cold water piping for supplying cold water
15 generated from a heat source machine to the condenser,

and further comprising:

second cold water piping for supplying the cold
water generated from the heat source machine to the
refrigerant liquid tank;

20 a refrigerant liquid temperature sensor for
measuring a temperature of the refrigerant liquid in the
refrigerant liquid tank; and

a control unit for controlling to supply the cold
water desired for condensation of the refrigerant gas to
25 the condenser.

[Claim 2]

The air conditioning system according to Claim 1,
wherein

the first cold water piping is series-connected with
5 the second cold water piping to flow the cold water from
the heat source machine to the condenser and the
refrigerant liquid tank in series.

[Claim 3]

The air conditioning system according to Claim 2,
10 wherein

the first cold water piping is connected with the
second cold water piping such that the cold water flows
from the heat source machine to the condenser via the
refrigerant liquid tank.

15 [Claim 4]

The air conditioning system according to any one of
Claims 1 to 3, further comprising:

pressure sensors for measuring a discharge pressure
and a suction pressure of the refrigerant pump; and

20 an inverter for changing an operating frequency of
the refrigerant pump,

wherein the operating frequency of the refrigerant
pump is controlled by the control unit such that a
differential pressure between the discharge pressure and
25 the suction pressure has a set value.

[Claim 5]

The air conditioning system according to any one of Claims 1 to 4, further comprising:

a zero point temperature detection unit for

5 detecting a zero point temperature in the room to be air-conditioned; and

a condensate temperature sensor for measuring a temperature of the refrigerant liquid liquefied by the condenser,

10 wherein when the temperature of the refrigerant liquid in the refrigerant liquid tank is lower than the zero point temperature detected by the zero point temperature detection unit, the flow rate of the cold water into the refrigerant liquid tank is adjusted such
15 that the temperature of the refrigerant liquid in the refrigerant liquid tank becomes higher than the zero point temperature in the room and the flow rate of the cold water into the condenser is adjusted such that the temperature of the liquefied refrigerant in the condenser
20 becomes higher than the temperature of the refrigerant liquid in the refrigerant liquid tank by the control unit.

[Claim 6]

The air conditioning system according to any one of Claims 1 to 5, wherein

25 an evaporating temperature is calculated from the

suction pressure of the refrigerant pump and the cold water is supplied to the refrigerant liquid tank such that the temperature of the refrigerant liquid in the refrigerant liquid tank becomes lower than the calculated
5 evaporating temperature by the control unit.

[Claim 7]

A method of operating an air conditioning system comprising:

an evaporator for vaporizing a refrigerant by
10 exchanging heat between the refrigerant and air in a room to be air-conditioned;

a condenser for liquefying a refrigerant gas vaporized by the evaporator;

a refrigerant pump for feeding a refrigerant liquid
15 liquefied by the condenser to the evaporator;

a refrigerant liquid tank disposed between the condenser and the refrigerant pump to temporarily store the refrigerant liquid liquefied by the condenser; and

cold water piping for supplying cold water generated
20 from a heat source machine to the condenser and the refrigerant liquid tank, and

controlling the operations of the above components by a control unit,

wherein cold water desired for condensation of the
25 refrigerant is supplied to the condenser.

[Claim 8]

The method of operating the air conditioning system according to Claim 7, wherein

the cold water piping for supplying the cold water
5 to the condenser is series-connected with the cold water piping for supplying the cold water to the refrigerant liquid tank to flow the cold water from the heat source machine to the condenser and the refrigerant liquid tank in series.

10 [Claim 9]

The method of operating the air conditioning system according to Claim 8, wherein

the cold water is supplied from the heat source machine to the condenser via the refrigerant liquid tank.

15 [Claim 10]

The method of operating the air conditioning system according to any one of Claims 7 to 9, wherein

a discharge pressure and a suction pressure of the refrigerant pump are measured and an operating frequency
20 of the refrigerant pump is controlled such that a differential pressure between the discharge pressure and the suction pressure has a set value.

[Claim 11]

The method of operating the air conditioning system
25 according to any one of Claims 7 to 10, further

comprising:

a zero point temperature detection unit for detecting a zero point temperature in the room to be air-conditioned; and

5 a condensate temperature sensor for measuring a temperature of the refrigerant liquid liquefied by the condenser,

wherein when the temperature of the refrigerant liquid in the refrigerant liquid tank is lower than the
10 zero point temperature detected by the zero point temperature detection unit, the flow rate of the cold water into the refrigerant liquid tank is adjusted such that the temperature of the refrigerant liquid in the refrigerant liquid tank becomes higher than the zero point
15 temperature in the room, and the flow rate of the cold water into the condenser is adjusted such that the temperature of the liquefied refrigerant in the condenser becomes higher than the temperature of the refrigerant liquid in the refrigerant liquid tank.

20 [Claim 12]

The method of operating the air conditioning system according to any one of Claims 7 to 11, wherein

an evaporating temperature is calculated from the suction pressure at an inlet of the refrigerant pump and
25 the cold water is supplied to the refrigerant liquid tank

such that the temperature of the refrigerant liquid in the refrigerant liquid tank becomes lower than the calculated evaporating temperature.