

HEAT SOURCE SYSTEM AND METHOD FOR CONTROLLING THE SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Japanese
5 Patent Application No. 2011-135446 filed on June 17, 2012,
the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

10 The present invention relates to a heat source system
and a method for controlling the same.

Description of the Related Art

A heat source system that produces cold water by a
15 chiller and cools a load (a room, an appliance or the like)
is well known. A chiller installed in such a heat source
system is controlled by a capacity corresponding to
increase and decrease in the load.

Some heat source systems include two or more chillers
20 arranged in series so that convey power is cut down by
increasing the temperature difference of cold water used
for cooling. See, for example, JP S61-225528 A (to be
referred to as Patent Document 1 hereinafter) and JP S60-
023760 A (to be referred to as Patent Document 2
25 hereinafter).

Nonpatent Literature 1: "Heat Storage Air-
conditioning System", The Society of Heating, Air-
conditioning and Sanitary Engineers of Japan, pp.82-85,
1998

30 The heat source systems disclosed in Patent Documents

1 and 2 can reduce the required pumping power of cold water by arranging in series the chillers on the high temperature side and the low temperature side and increasing the temperature difference therebetween, for example in a condition where outside air temperature is high and temperature difference of cold water while circulation (temperature difference between the inlet side of the chiller and the outlet side of the chiller) is large.

However, if the chillers are arranged in series, and when the flow rate of a pump which feeds cold water into the chiller is constant, the efficiency of the heat source system may be lowered when cooling load is a partial load which is smaller than the maximum capacity (maximum load), and therefore there is a problem that the efficiency of the heat source system may be dropped due to change in load of an object to be cooled and condition of outside air. In addition, it is necessary to deal with load changes considering storage of heat of the thermal storage tank used for storing cold water.

In light of the above, the present invention addresses providing a heat source system that is capable of improving the efficiency when chillers arranged in series are not operated with a maximum load and a method for controlling the same.

SUMMARY OF INVENTION

To solve the problems above, according to a first aspect of the present invention, there is provided a heat source system, including: a cooling tower; a first cold water system configured to circulate first cold water cooled by the cooling tower; a second cold water

system configured to circulate second cold water used for cooling a load component; a plurality of chillers arranged in series to the second cold water system and configured to cool the second cold water by transferring heat of the second cold water used for cooling the load component to the first cold water; a control device that controls one or more objects to be controlled, the objects to be controlled including at least one of a cooling fan configured to send outside air to the cooling tower, a first pump configured to circulate the first cold water, and a second pump configured to circulate the second cold water; and a thermal storage unit configured to store the second cold water cooled by the chillers and provide the second cold water to the load component.

In addition, the control device sets a desired control value of the object to be controlled such that an evaluation function indicating an energy consumption becomes minimum in response to change in condition of outside air, and at least one of storage of heat of the thermal storage unit and a requirement load of the load component.

According to a second aspect of the present invention, there is provided a method for controlling a heat source system that includes: a cooling tower; a first cold water system configured to circulate first cold water cooled by the cooling tower; a second cold water system configured to circulate second cold water cooling a load component; a plurality of chillers arranged in series to the second cold water system and configured to cool the second cold water by transferring heat of the second cold water used for

cooling the load component to the first cold water; a control device that controls one or more objects to be controlled, the objects to be controlled including at least one of a cooling fan configured to send outside air to the cooling tower, a first pump configured to circulate the first cold water, and a second pump configured to circulate second cold water; and a thermal storage unit configured to store the second cold water cooled by the chillers and provide the second cold water to the load component, the method comprising the steps of: setting a desired control value of the object to be controlled such that an evaluation function indicating energy consumption becomes minimum in response to change in condition of outside air and at least one of storage of heat of the thermal storage unit and a requirement load of the load component; and controlling the one or more objects to be controlled in accordance with the desired control value.

According to embodiments of the present invention, it is possible to provide a heat source system capable of improving efficiency when chillers arranged in series are not operated at a maximum load and to provide a method for controlling the same.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating a configuration example of a heat source system according to the present embodiment;

FIG. 2A is a graph showing a relation between a load factor and COP of a chiller in a case when the desired value of an object to be controlled is kept constant;

FIG. 2B is a graph showing a relation between a load factor and COP of a chiller in a case when the desired value of an object to be controlled is determined based on a optimization calculation;

FIG. 3 is a flow chart illustrating a procedure of heat storage operation;

FIGS. 4A and 4B are graphs illustrating examples of change in cooling amount;

FIG. 5 is a flow chart illustrating a procedure of running heat storage operation and cooling operation in response to a load;

FIG. 6 is a diagram illustrating an example of a data table showing relations among a wet-bulb temperature of outside air, a load factor of the chiller, and a ratio of rotational speed of a cooling water pump;

FIG. 7 is a diagram illustrating a configuration example of the heat source system in which a high temperature side chiller and a low temperature side chiller are arranged in series to the cooling water system; and

FIG. 8 is a diagram illustrating a configuration example of the heat source system including two cooling towers.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENT

Embodiments of the present invention will be described in detail with reference to the related drawings according to the necessity.

The heat source system 100 according to the present

embodiment is configured by, as shown in FIG. 1, thermally connecting a first cold water system (a cooling water system) in which a first cold water (a cooling water) cooled by free cooling in a cooling tower 1 is circulated and a second cold water system (a cooling water system) in which a second cold water (a cold water) that cools a load 3 is circulated via a high temperature side chiller 2a and a low temperature side chiller 2b. The high temperature side chiller 2a and the low temperature side chiller 2b are centrifugal chiller for example and are arranged in series in the cold water system.

The heat of cold water whose temperature is risen by cooling the load 3 is transferred to the cooling water in the high temperature side chiller 2a and the low temperature side chiller 2b, thereby the cold water being cooled.

Meanwhile, the high temperature side chiller 2a is installed upstream of the cold water and the low temperature side chiller 2b is installed downstream of the cold water in the cold water system.

In the cooling water system, a high temperature side cooling water pump 4a and a high temperature side chiller 2a are arranged on a cooling water outgoing flow pipe 61a which is connected to the outlet side of the cooling tower 1. Cooling water cooled by the cooling tower 1 is flown into the high temperature side chiller 2a via the cooling water pump 4a. The outlet side of the high temperature side chiller 2a is connected to the inlet side of the cooling tower 1 via the cooling water incoming flow pipe 62a. The cooling water flown out from the high temperature

side chiller 2a is flown into the cooling tower 1.

Further, on the cooling water outgoing flow pipe 61a, a branched flow pipe 61b is connected between the outlet side of the cooling tower 1 and the high temperature side cooling water pump 4a. On the branched flow pipe 61b, a low temperature side cooling water pump 4b and a low temperature side chiller 2b are arranged, and some of the cold water cooled by the cooling tower 1 is flown into the low temperature side chiller 2b via the low temperature side cooling water pump 4b. On the outlet side of the low temperature side chiller 2b, a branched incoming flow pipe 62b is connected. The branched incoming flow pipe 62b is further connected to the cooling water incoming flow pipe 62a between the outlet side of the high temperature side chiller 2a and the inlet side of the cooling tower 1.

In other words, the high temperature side chiller 2a and the low temperature side chiller 2b are connected in parallel in the cooling water system. In the present embodiment, the high temperature side cooling water pump 4a and the low temperature side cooling water pump 4b altogether are referred to as a first pump.

The cooling tower 1 is provided with a cooling fan 6 which is driven by an inverter 51. The cooling water flown into the cooling tower 1 is cooled by outside air circulated by the cooling fan 6. The rotational speed of the cooling fan 6 is controlled with a frequency inputted to the inverter 51.

That is, the air flow rate to the cooling tower 1 is controlled with a frequency inputted to the inverter 51.

The high temperature side cooling water pump 4a is

driven by an inverter 52a, and the low temperature side cooling water pump 4b is driven by an inverter 52b. A cooling tower outlet temperature (cooling water temperature at the cooling tower outlet) sensor 31 that measures the outlet temperature of cooling water in the cooling tower 1 is set up on the outlet side of the cooling tower 1.

Rotational speeds of the high temperature side cooling water pump 4a and the low temperature side cooling water pump 4b are controlled with a frequency inputted to the inverters 52a and 52b respectively.

That is, the flow rate of cooling water in the cooling water system is controlled with a frequency inputted to the inverters 52a and 52b.

The cold water system is configured such that the outlet side of a thermal storage tank 8 and the inlet side of the high temperature side chiller 2a are connected via a cold water incoming flow pipe 64 which is provided with a cold water pump 5. Further, the outlet side of the high temperature side chiller 2a and the inlet side of the low temperature side chiller 2b are connected via a chiller connecting pipe 65. Further, the outlet side of the low temperature side chiller 2b is connected to the inlet side of the thermal storage tank 8 via a cold water outgoing flow pipe 63. The cold water pump 5 is driven by an inverter 53.

Rotational speed of the cold water pump 5 is controlled with a frequency inputted to the inverter 53. That is, the flow rate of the cold water in the cold water system is controlled with a frequency inputted to the inverter 53. In this embodiment, the cold water pump 5 is

referred to as a second pump.

The cold water system is provided with a high temperature side chiller outlet temperature sensor 34a that measures outlet temperature of cold water in the high temperature side chiller 2a (hereinafter referred to as cold water temperature of high temperature chiller outlet), a low temperature side chiller outlet temperature sensor 34b that measures outlet temperature of cold water in the low temperature side chiller 2b (hereinafter referred to as cold water temperature of low temperature chiller outlet), and a thermal storage tank temperature sensor 8a that measures temperature of cold water in the thermal storage tank 8 (hereinafter referred to as thermal storage tank temperature) . Here, the thermal storage tank temperature sensor 8a may be omitted.

The heat source system 100 is provided with a secondary cold water system which is configured including the thermal storage tank 8 and a load 3.

In the secondary cold water system, the outlet side of the thermal storage tank 8 and the inlet side of the load 3 are connected via a secondary cooling outgoing flow pipe 66 which includes a secondary cold water pump 5a, and the outlet side of the load 3 and a secondary inlet side of the thermal storage tank 8 are connected via a secondary cooling incoming flow pipe 67. According to this configuration, cold water is provided to the load 3 via the thermal storage tank 8.

The secondary cold water pump 5a is driven by an inverter 53a.

Further, there are provided a thermal storage tank

secondary outlet temperature sensor 81 that measures temperature of secondary outlet in the thermal storage tank 8 (hereinafter referred to as cold water temperature of thermal storage tank secondary outlet), a thermal storage tank secondary inlet temperature sensor 82 that measures temperature of secondary inlet of cold water in the thermal storage tank 8 (hereinafter referred to as cold water temperature of thermal storage tank secondary inlet), and a flowmeter 83 that measures flow rate of cold water in the secondary cold water system.

The thermal storage tank 8 is for example a water tank storing cold water, or a thermal storage unit storing cold energy by storing cold water cooled by the high temperature side chiller 2a and the low temperature side chiller 2b. The load 3 is configured to be cooled by heat quantity provided by the thermal storage tank 8. The high temperature side chiller 2a and the low temperature side chiller 2b accumulate heat quantity into the thermal storage tank 8 by cooling the cold water stored in the thermal storage tank 8.

The thermal storage tank 8 is configured such that, for example, the secondary cooling outgoing flow pipe 66 is connected to the vicinity of the cold water outgoing flow pipe 63 and the cold water incoming flow pipe 64 is connected to the vicinity of the secondary cooling incoming flow pipe 67. In addition, it is preferable that the thermal storage tank 8 be configured such that, when the cold water pump 5 and the secondary cold water pump 5a are working, the cold water flown into the thermal storage tank 8 through cold water outgoing flow pipe 63 should be flown

into the secondary cooling outgoing flow pipe 66, while cold water flown into the thermal storage tank 8 through the secondary cooling incoming flow pipe 67 should be flown into the cold water incoming flow pipe 64.

5 In addition, it is preferable that when the cold water pump 5 is working and the secondary cold water pump 5a is not working, the cold water flown into the thermal storage tank 8 through the cold water outgoing flow pipe 63 should be stored from the cold water outgoing flow pipe 63
10 side. Similarly, it is preferable that the thermal storage tank 8 is configured such that, when the cold water pump 5 is not working and the secondary cold water pump 5a is working, cold water stored in the vicinity of the cold water outgoing flow pipe 63 should be flown into the
15 secondary cooling outgoing flow pipe 66 while cold water flown into the thermal storage tank 8 through the secondary cooling incoming flow pipe 67 should be stored in the vicinity of the secondary cooling incoming flow pipe 67.

 According to this configuration, the thermal storage
20 tank 8 works as a pipe when the cold water pump 5 and the secondary cold water pump 5a are working. When the cold water pump 5 is working and the secondary cold water pump 5a is not working, the thermal storage tank 8 works as a buffer that stores cold water (i.e. cold energy is stored).
25 In addition, when the cold water pump 5 is not working and the secondary cold water pump 5a is working, the thermal storage tank 8 works as a buffer that provides cold water (i.e. provides stored heat quantity) to the load 3.

 Further, when the flow rate of the cold water pump 5
30 is higher than that of the secondary cold water pump 5a,

heat quantity corresponding to the difference of the flow rates is stored in the thermal storage tank 8. Similarly, when the flow rate of the cold water pump 5 is lower than that of the secondary cold water pump 5a, heat quantity
5 corresponding to the difference of the flow rates is provided to the load 3 from the thermal storage tank 8.

Further, the heat source system 100 is provided with an outside air temperature indicator 37 that measures outside air temperature and an outside air hygrometer 38
10 that measures outside air humidity.

Thus the heat source system 100 according to the present embodiment is configured including the cooling water system, the cold water system and the secondary cold water system. Cooling water circulating in the cooling
15 water system and cold water circulating in the cold water system is cooled by heat exchange conducted in the high temperature side chiller 2a and the low temperature side chiller 2b.

Then, the cold water is provided into the load 3
20 (room, appliance or the like) via the thermal storage tank 8, thereby cooling the load 3. The operation thus performed by the heat source system 100 is referred to as cooling operation.

In addition, heat quantity is stored in the thermal
25 storage tank 8 by storing the cold water cooled by the high temperature side chiller 2a and the low temperature side chiller 2b into the thermal storage tank 8. The operation for storing heat quantity to the thermal storage tank 8 is referred to as heat storage operation.

30 In this configuration, the cooling fan 6, the high

temperature side cooling water pump 4a, the low temperature side cooling water pump 4b, the cold water pump 5 and the secondary cold water pump 5a provided to the heat source system 100 are controlled by the control device 71.

5 Hereinafter in this embodiment, the high temperature side chiller 2a and the low temperature side chiller 2b altogether are referred to as a chiller.

Note that in FIG. 1, although a configuration is shown including two chillers (the high temperature side chiller 2a, the low temperature side chiller 2b), another
10 configuration may be possible including three or more chillers arranged in series in the cold water system. Further, although not shown in the figure, another configuration may be possible including a plurality of
15 groups of chillers arranged in parallel, each group including a plurality of chillers arranged in series.

According to the control device 71 of the present embodiment, wet-bulb temperature is calculated from outside air temperature measured by the outside air temperature
20 indicator 37 and outside air humidity measured by the outside air hygrometer 38. Further, a load required by the load 3 is calculated based on a flow rate of cold water in the secondary cold water system, cold water temperature of thermal storage tank secondary inlet, and cold water
25 temperature of thermal storage tank secondary outlet. Then rotational speed of the secondary cold water pump 5a is controlled by stabilizing control of discharging pressure and stabilizing control of end pressure in accordance with the load required by the load 3. Namely, the flow rate of
30 cold water in the secondary cold water system is controlled.

The stabilizing control of discharging pressure and stabilizing control of end pressure can utilize techniques known to the public. Hereinafter the load required by the load 3 is referred to as requirement load.

5 Here, another configuration may be possible in which, instead of the outside air temperature indicator 37 and the outside air hygrometer 38, a wet-bulb thermometer which is not shown may be provided.

10 The requirement load of the load 3 is a load when the load 3 is cooled by cold water, and the value is determined by conditions of the load 3 such as room temperature, device temperature or the like.

15 The requirement load of the load 3 is calculated based on the cold water flow rate, the cold water temperature of thermal storage tank secondary inlet, the cold water temperature of thermal storage tank secondary outlet in the secondary cold water system. Meanwhile, the thermal storage tank secondary outlet temperature sensor 81 may be omitted, and the set value of the cold water
20 temperature of thermal storage tank secondary outlet may be used as a requirement load of the load 3. According to this configuration, the thermal storage tank secondary outlet temperature sensor 81 is not necessary and the structure of the heat source system 100 can be simplified.

25 The control device 71 controls the high temperature side chiller 2a and the low temperature side chiller 2b with a desired value of the outlet temperature of cold water in the high temperature side chiller 2a and another desired value of the outlet temperature of cold water in
30 the high temperature side chiller 2b respectively.

Alternatively, the chillers may be configured to have a control function such that each of the chillers (the high temperature side chiller 2a and the low temperature side chiller 2b) is provided with a control feature that maintains the outlet temperature of cold water (cold water temperature of high temperature chiller outlet, cold water temperature of low temperature chiller outlet) to be constant, and maintains the desired value of the outlet temperature of cold water indicated by the control device 71.

Further, the control device 71 controls rotational speed of the cooling fan 6 (air flow rate of the cooling tower 1) so that the cooling water temperature at the cooling tower outlet becomes the desired value.

The control device 71 according to the present embodiment performs optimization calculation of the water temperature and the flow rate of cold water and cooling water such that the energy consumption which is predicted based on varying outside air conditions (wet-bulb temperature in particular), requirement load of the load 3, and characteristics of devices constituting the heat source system 100 (resistance of cooling water and cold water in the devices and pipes) becomes minimum. Then, the control device 71 changes the desired values of the temperature of cooling water (cooling water temperature at the cooling tower outlet), the temperature of cold water (cold water temperature of high temperature chiller outlet, cold water temperature of low temperature chiller outlet), the flow rate of cooling water (the flow rate ratio of cooling water or the rotational speed of the cooling water pumps 4a and

4b), the flow rate of cold water (the flow rate ratio of cold water or the rotational speed of the cold water pumps 5a and 5b) based on the result of the optimization calculation.

5 Note that the flow rate ratio of cooling water is a ratio of cooling water of the cooling water pumps 4a and 4b relative to the flow rate in the rated operation, and the flow rate ratio of cold water is a ratio of cold water of the cold water pump 5 relative to the flow rate in the
10 rated operation.

 According to this configuration in the present embodiment, the control device 71 controls the high temperature side cooling water pump 4a, the low temperature side cooling water pump 4b, the cold water pump 5, and the
15 cooling fan 6. The control device 71 sets desired values for these objects to be controlled through optimization calculation, and controls the heat source system 100.

 In a case of cooling operation cooling the load 3 by cold water for example, the control device 71 sets the
20 requirement load of the load 3 as a load to be processed by the chiller (hereinafter referred to as chiller load).

 Then the control device 71 simulates a sum total of energy consumption of the objects to be controlled (the high temperature side cooling water pump 4a, the low
25 temperature side cooling water pump 4b, the cold water pump 5, and the cooling fan 6). The simulation is performed using the chiller load, the wet-bulb temperature of outside air, the cooling water temperature at the cooling tower outlet, the cold water temperature of high temperature
30 chiller outlet, the cold water temperature of low

temperature chiller outlet, the flow rate of cooling water, and the flow rate of cold water as parameters. The simulation is performed also based on the resistance of cold water in the high temperature side chiller 2a, the low
5 temperature side chiller 2b, and the cold water pump 5 (flow channel resistance), and the resistance of cooling water in the high temperature side chiller 2a, the low temperature side chiller 2b, the high temperature side cooling water pump 4a, the low temperature side cooling
10 water pump 4b, and the cooling tower 1.

The control device 71 calculates the lifting height of each of the pumps (high temperature side cooling water pump 4a, low temperature side cooling water pump 4b, and
15 cold water pump 5) based on the result of predictions and measurements of relation of pressure loss to the flow rates of cooling water and cold water in the pipes (cooling water outgoing flow pipe 61a, branched flow pipe 61b, cooling water incoming flow pipe 62a, branched incoming flow pipe
20 62b, cold water outgoing flow pipe 63, cold water incoming flow pipe 64, and chiller connecting pipe 65). Then the control device 71 calculates pumping power of each of the pumps from the relation between the flow rate and the lifting height. Further, the control device 71 calculates energy consumption of each of the pumps from the calculated
25 pumping power of each pump.

In addition, the control device 71 predicts power consumption of the cooling tower 1 by calculates air volume ratio of the cooling fan 6 corresponding to outside air conditions, the flow rate of cooling water, the temperature
30 of cooling water (cooling water temperature at the cooling

tower outlet, cooling water temperature at the cooling tower inlet) from the performance of the cooling tower 1 using generic overall volumetric enthalpy-transfer coefficient and cooling tower performance approximation.

5 Here, the air volume ratio of the cooling fan 6 is a ratio relative to the air volume of the cooling fan 6 in the rated operation.

 In addition, the energy consumption of the chiller is predicted as energy consumption of the chiller when
10 operated with the chiller load.

 Further, the control device 71 searches an optimization variable such that an evaluation function W shown with the formula (1) becomes minimum, and then determines the desired control value of the object to be
15 controlled based on the searched optimization variables. Here, the evaluation function W is a total sum of energy consumption of the heat source system 100. And quantity of chillers, the flow rate of the cold water and cooling water (the rotational speed of each of the pumps), and the
20 temperature of the cold water and cooling water are optimization variables.

$$W = E_{ref1} + E_{ref2} + E_{cp} + E_{cwp1} + E_{cwp2} + E_{ct} \dots (1)$$

where

25 E_{ref1} : energy consumption of high temperature side chiller [kW] ,

E_{ref2} : energy consumption of low temperature side chiller [kW] ,

E_{cp} : energy consumption of cold water pump [kW] ,

30 E_{cwp1} : energy consumption of high temperature side

cooling water pump [kW] ,

Ecwp2: energy consumption of low temperature side cooling
water pump [kW] and

Ect: energy consumption of cooling tower [kW] .

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In other words, the control device 71 sets desired
values of the flow rate of the cooling water, the flow rate
of the cold water, the cold water temperature of high
temperature chiller outlet, the cold water temperature of
10 low temperature chiller outlet, and the cooling water
temperature at the cooling tower outlet such that the
evaluation function W shown with the formula (1) becomes
minimum.

More specifically, the control device 71 determines
15 each of the energy consumption of the high temperature side
chiller 2a (Eref1), the energy consumption of the low
temperature side chiller 2a (Eref2), the energy consumption
of the cold water pump 5 (Ecp), the energy consumption of
the high temperature side cooling water pump 4a (Ecwp1),
20 the energy consumption of the low temperature side
cooling water pump 4b (Ecwp2), the energy consumption of
the cooling tower 1 (Ect) such that the evaluation function
 W becomes minimum. And then, the flow rate of the cooling
water, flow rate of cold water, cold water temperature of
25 high temperature chiller outlet, cold water temperature of
low temperature chiller outlet, and the cooling water
temperature at the cooling tower outlet at that time are
set as desired values respectively.

Further, the control device 71 sets desired control
30 values of the objects to be controlled (high temperature

side cooling water pump 4a, low temperature side cooling water pump 4b, cold water pump 5, and cooling fan 6) such that the flow rates of the cooling water (the flow rate of cooling water in the high temperature side chiller 2a, the
5 flow rate of cooling water in the low temperature side chiller 2b), the flow rate of cold water, the cold water temperature of high temperature chiller outlet, the cold water temperature of low temperature chiller outlet, and the cooling water temperature at the cooling tower outlet
10 becomes the specified desired values.

More specifically, the control device 71 determines a desired control value of the rotational speed of the high temperature side cooling water pump 4a such that the flow rate of cooling water in the high temperature side chiller
15 2a becomes the specified desired value. Similarly, the control device 71 determines a desired control value of the rotational speed of the low temperature side cooling water pump 4b such that the flow rate of cooling water in the low temperature side chiller 2b becomes the specified desired
20 value, and determines a desired control value of the rotational speed of the cold water pump 5 such that the flow rate of cold water becomes the specified desired value, and further determines a desired control value of the rotational speed of the cooling fan 6 such that the cooling
25 water temperature at the cooling tower outlet becomes the specified desired value. The control device 71 may be configured such that the cooling water temperature at the cooling tower outlet is kept to a desired value by on/off control of the cooling fan 6 or by feedback control of the
30 rotational speed such that the measurement value of the

cooling tower outlet temperature sensor 31 becomes constant. According to this configuration, even when outside air condition is changed for example, the cooling water temperature at the cooling tower outlet can be kept to the
5 specified desired value with a high degree of accuracy.

Further, the control device 71 controls the objects to be controlled based on the desired control values.

In addition, the control device 71 operates the high temperature side chiller 2a and the low temperature side
10 chiller 2b using the requirement load of the load 3 as a operating load. More specifically, the control device 71 performs partial load operation of the high temperature side chiller 2a and the low temperature side chiller 2b such that the total sum of the operating load of the high
15 temperature side chiller 2a and the operating load of the low temperature side chiller 2b equals to the requirement load of the load 3.

In this case, it may be configured such that a value obtained by dividing the requirement load by operating load
20 of each chiller equals to the number of chillers.

Further, it may be configured such that the operating load is equally shared by the high temperature side chiller 2a and the low temperature side chiller 2b.

According to this configuration, even when the
25 chillers (high temperature side chiller 2a, low temperature side chiller 2b) are not operated with a maximum load, it is possible to perform partial load operation of the heat source system 100 keeping the COP (Coefficient of Performance) thereof at high level, and to achieve energy
30 conservation.

Further, it is preferable that the control device 71 should change the setting of desired control value with a predetermined time interval (e.g. 10 minutes interval) following the outside air condition and the change of the requirement load of the load 3. According to this configuration, the heat source system 100 can keep the COP at high level even when the wet-bulb temperature of outside air and the load of the load 3 are changed.

Meanwhile, in the optimization calculation, the load allocation of the high temperature side chiller 2a and the low temperature side chiller 2b may be set to a fixed value and the outlet temperature of cold water (cold water temperature of high temperature chiller outlet, cold water temperature of low temperature chiller outlet) may be changed arbitrary by an operator of the heat source system 100 for example. According to this configuration, it is possible to deal with a case when the outlet temperature of cold water of the chillers (high temperature side chiller 2a, low temperature side chiller 2b) cannot be changed due to failure or maintenance for example.

In addition, it is possible to achieve energy conservation when one of the high temperature side chiller 2a and the low temperature side chiller 2b is operated for example.

FIG. 2A is a graph showing a relation between the load factor and COP of the chiller in a case when desired values of objects to be controlled (high temperature side cooling water pump 4a, low temperature side cooling water pump 4b, cold water pump 5, cooling fan 6) are kept constant. FIG. 2B is a graph showing a change of COP in a

case when the desired value is determined based on optimization calculation. In FIGS. 2A and 2B, the load factor is shown as 200% when both the load factors of the high temperature side chiller 2a (see FIG. 1) and the low temperature side chiller 2b (see FIG. 1) are 100%. The load factor here means a ratio of the operating load of the chiller relative to the maximum load.

Since a centrifugal chiller operated in a constant rotational speed performs the maximum efficiency when operated around the nominal load, the efficiency becomes high when the temperature difference is in a specified value. In addition, the cold water temperature of high temperature chiller outlet and the cold water temperature of low temperature chiller outlet are set as designed values of the heat source system 100 (see FIG. 1). Accordingly, in the cold water system, the maximum load of each of the chillers are determined such that each of the high temperature side chiller 2a and the low temperature side chiller 2b are operated efficiently at the predetermined temperature difference of the cold water temperature of high temperature chiller inlet and the cold water temperature of low temperature chiller outlet.

However, there is a case when the cold water temperature of high temperature chiller inlet is changed in response to a change of wet-bulb temperature of outside air and a requirement load of the load 3, and the temperature difference of the high temperature side chiller 2a (difference between the cold water temperature of high temperature chiller inlet and the cold water temperature of high temperature chiller outlet) becomes small. In such a

case, the high temperature side chiller 2a is not operated with the maximum load, and the efficiency is lowered.

FIG.2A illustrates this state showing that the COP of the heat source system 100 (see FIG. 1) is lowered with
5 lowering of the load factor of the chiller when the desired control value of the object to be controlled is kept constant.

In contrast, the control device 71 (see FIG. 1) executes optimization calculation when wet-bulb temperature
10 of outside air or the load of the load 3 (see FIG. 1) is changed such that the evaluation function W , which is sum total of energy consumption of the heat source system 100 (see FIG. 1), becomes minimum. Then the control device 71 sets the desired control value of the object to be
15 controlled in accordance with the optimization calculation, and controls the object to be controlled. Further, the control device 71 performs partial load operation of the high temperature side chiller 2a and the low temperature side chiller 2b.

20 FIG.2B illustrates this state showing that the COP of the heat source system 100 (see FIG. 1) is kept high even when the wet-bulb temperature of outside air or the load of the load 3 is changed and the high temperature side chiller 2a and the low temperature side chiller 2b are operated
25 with partial load.

As explained above, the heat source system 100 (see FIG. 1) according to the present embodiment is configured such that, when the wet-bulb temperature of outside air or the load of the load 3 is changed, the control device 71
30 (see FIG. 1) executes optimization calculation, sets the

desired control value of the object to be controlled, and keeps the COP in operation at high level.

That is, the heat source system 100 (see FIG. 1) according to the present embodiment can keep the COP in
5 operation high and achieve energy conservation by changing appropriately the load balance of the high temperature side chiller 2a (see FIG. 1) and the low temperature side chiller 2b (see FIG. 1) arranged in series.

Meanwhile, instead of configuring the control device
10 71 (see FIG. 1) to execute optimization calculation according to the change of the wet-bulb temperature of outside air or change of the load of the load 3, it may be configured to prepare in advance a data table holding correspondences among the wet-bulb temperature of outside
15 air, the requirement load of the load 3, and desired control value that makes the evaluation function minimum.

According to this configuration, the control device 71 can set the desired control value of the object to be controlled to make the evaluation function minimum by
20 referring to the data table based on the wet-bulb temperature of outside air and the requirement load of the load 3 without executing optimization calculation. Therefore, it is possible to reduce the calculation load of the control device 71.

25 Such a data table may be generated by, inputting the wet-bulb temperature of outside air and the load of the load 3 (see FIG. 1) into a simulator modeling the heat source system 100 (see FIG. 1), executing the aforementioned optimization calculation, and setting the
30 desired control value of the object to be controlled

corresponding to the inputted wet-bulb temperature and the load.

Then the data table is stored in a memory (not shown) in the control device 71 (see FIG. 1). Thus the control
5 device 71 can refer to the data table in accordance with the wet-bulb temperature of outside air and the requirement load of the load 3, and set a desired control value of the object to be controlled.

Still Further, the heat source system 100 (see FIG.
10 1) according to the present embodiment may be configured to accumulate heat into the thermal storage tank 8 by heat accumulating operation executed in a specific heat storing term based on a predetermined schedule. It is possible for the control device 71 (see FIG. 1) to keep the COP of the
15 heat source system 100 in high level by executing the optimization calculation using the load that corresponds to the load factor of high COP as the load of the chiller.

It is preferable that the time schedule of heat storage operation of the heat source system 100 should be
20 set in specific time period (monthly, weekly etc.) based on yearly change pattern of outside air for example such that the heat storage operation is performed in a time slot when energy consumption becomes minimum.

Further, the control device 71 (see FIG. 1) may be
25 provided with a calendar function and may perform heat storage operation according to predetermined time schedule, thereby suppressing energy consumption in the heat storage operation of the heat source system 100.

Still further, it is preferable that the load factor
30 in heat storage operation should be stored in a memory (not

shown) as predicted data based on yearly load pattern and outside air condition in the past for example, and the control device 71 should be configured to read out the data from the memory and set the load factor. According to this
5 configuration, the control device 71 can predict a case in which the heat source system 100 performs heat storage operation with a load factor of high COP and the storage of heat of the thermal storage tank 8 does not become the maximum value, and set the load factor. Thus it is
10 possible to prevent the storage of heat of the thermal storage tank 8 in heat storage operation from becoming the maximum value.

Referring to FIG. 3, procedure of the control device 71 when performing the heat storage operation will be
15 explained (see FIGS. 1 and 2 as needed).

In a case when time schedule is made having a heat storage operation time from 8:00 PM (20:00) to 8:00 PM next morning, the control device 71 calculates at 20:00 the heat quantity to be stored in the thermal storage tank 8 and the
20 wet-bulb temperature of outside air (step S100).

More specifically, the control device 71 checks the storage of heat of the thermal storage tank 8, and calculates a shortage of heat quantity relative to a predetermined storage of heat (rated storage of heat), and
25 then sets the shortage as heat quantity to be stored.

For example, the control device 71 calculates necessary heat quantity for lowering the temperature of the thermal storage tank 8 to a predetermined temperature and sets the heat quantity (cooling quantity) to be stored.

30 In addition, the control device 71 sets up a chiller

load (step S101).

For example, in a case when a load corresponding to a load factor that makes the COP shown in FIG. 2B maximum has been set, the COP of the heat source system 100 in heat storage operation can be kept at the maximum.

Then the control device 71 executes optimization calculation such that the evaluation function W shown with the formula (1) becomes minimum as described above using the chiller load, wet-bulb temperature of outside air, cooling water temperature at the cooling tower outlet, cold water temperature of high temperature chiller outlet, cold water temperature of low temperature chiller outlet, flow rate cooling water, and flow rate of cold water as parameters (step S102).

Further, the control device 71 controls the object to be controlled in accordance with the desired control value that has been set based on the optimization calculation (step S103).

The control device 71 is capable of performing heat storage operation operating the chiller with a chiller load that makes the COP maximum by repeatedly executing the procedures of steps S100 to S103 with a predetermined time interval (e.g. 10 minutes).

Conventionally, as shown in FIG. 4A, the heat source system 100 performs heat storage operation operating the chillers with such a chiller load that makes the cooling amount 100% during the heat storing term from 8:00 PM to 8:00 AM next morning. Here, in FIGS. 4A and 4B, the cooling amount is shown as 100% when the load factor is 200%.

However, as shown in FIG. 2B, if the COP of the heat source system 100 does not become maximum when the load factor is 200%, the energy consumption can be more reduced when operating the chiller with the load factor (e.g. 150%) that makes the COP of the heat source system 100 maximum compared to when operating with the load factor 200%.

In this case, as shown in FIG. 4B, since the cooling amount per one hour is less than 100%, energy consumption can be reduced although the heat storage operation time (operation hour of the chiller) is longer.

In other words, the total area of the bar graph shown in FIG. 4B (area of hatched portion) is less than the total area of the bar graph shown in FIG. 4A.

As described above, the heat source system 100 (see FIG. 1) according to the present embodiment can operate the chillers (high temperature side chiller 2a, low temperature side chiller 2b) with a load factor that makes the COP of the heat source system 100 maximum in the heat storage operation, and can achieve energy conservation in the heat storage operation.

In addition, the heat source system 100 (see FIG. 1) according to the present embodiment can also be configured to perform, in response to the requirement load of the load 3 (see FIG. 1) during cooling operation, partial load operation of the chiller with a operating load corresponding to the load factor of the maximum COP, and compensates the difference between the operation load of the chiller and the requirement load of the load 3 using storage of heat in the thermal storage tank 8.

For example, when a load factor of the chiller

corresponding to the requirement load of the load 3 is 200%, and if a load factor corresponding to the maximum COP is lower than 200% (e.g. 150%), then the heat source system 100 may be operated with the load factor corresponding to the maximum COP, and the shortage to the requirement load may be compensated using storage of heat in the thermal storage tank 8.

In this case, if the cooling capacity of the thermal storage tank 8 is large, changes of requirement load of the load 3 can be absorbed by the storage of heat of the thermal storage tank 8, and the load of the chiller for storing heat to the thermal storage tank 8 can be kept constant.

On the other hand, if the cooling capacity of the thermal storage tank 8 is small and when the storage of heat of the thermal storage tank 8 is to be consumed, the requirement load of the load 3 may exceed the storage of heat of the thermal storage tank 8. In this case, the heat source system 100 cannot compensate the shortage relative to the requirement load using heat storage in the thermal storage tank 8. Therefore, it is preferable that the heat source system 100 should be configured to operate the chiller with a load factor that corresponds to the requirement load of the load 3.

Referring to FIG. 5, will be explained a procedure of the chiller with a load factor that makes the COP of the heat source system 100 (see FIG. 1) maximum while the control device 71 (see FIG. 1) is storing heat to the thermal storage tank 8 (see FIGS. 1 and 2 as needed).

First, the control device 71 calculates a load for

cooling the load 3 with cold water (requirement load of the load 3) and the wet-bulb temperature of outside air (step S1).

5 As stated before, the requirement load of the load 3 can be calculated based on the flow rate of cold water in the secondary cold water system, cold water temperature of thermal storage tank secondary inlet, and cold water temperature of thermal storage tank secondary outlet.

10 Further, the control device 71 calculates storage of heat of the thermal storage tank 8 based on an operating load of the high temperature side chiller 2a and the low temperature side chiller 2b and a load of the load 3 (step S2). More specifically, the control device 71 calculates a heat quantity which can be stored into the thermal storage
15 tank 8 based on the difference between the operating load of the chiller and the load of the load 3. Then storage of heat of the thermal storage tank 8 is calculated as an integral of the calculated heat quantity during the term of the operation of the heat source system 100.

20 In a case when the calculated storage of heat is lower than the lower limit (Yes, at step S3), the control device 71 compares the requirement load of the load 3 and the current operating load of the chiller (step S4). Then, if the requirement load is smaller than the operating load
25 (Yes, at step S4), the control device 71 sets a predetermined load for heat storage operation as a chiller load (step S5). If the requirement load is larger than or equal to the operating load (No, at step S4), the control device 71 sets the requirement load of the load 3 as a
30 chiller load (step S6).

It is preferable that the predetermined load for heat storage operation should be, for example, a load corresponding to a load factor that makes the COP of the heat source system 100 maximum as stated before.

5 In addition, it is preferable that the lower limit of the storage of heat should be set in advance as a design factor of the thermal storage tank 8.

Meanwhile, the control device 71 may be configured such that, when comparing the storage of heat of the thermal storage tank 8 and a lower limit, if the thermal storage tank temperature measured by the thermal storage tank temperature sensor 8a is higher than a predetermined threshold, control device 71 determines that the storage of heat of the thermal storage tank 8 is lower than the lower limit. In this case, it is preferable that the lower limit of the storage of heat should have been set to the threshold value.

Then the control device 71 executes optimization calculation such that an evaluation function W shown with the formula (1) becomes minimum, using a chiller load, wet-bulb temperature of outside air, cooling water temperature at the cooling tower outlet or the rotational speed ratio of the cooling fan 6, cold water temperature of high temperature chiller outlet, cold water temperature of low temperature chiller outlet, rotational speed ratio or flow rate ratio of cooling water of the high temperature side cooling water pump 4a and low temperature side cooling water pump 4b, and rotational speed ratio or flow rate of cold water of the pump 5 as parameters (step S7), and then sets a desired value of the object to be controlled.

Then, the control device 71 controls the object to be controlled based on the desired value (step S8).

Here, the rotational speed ratio of the cooling fan 6, the rotational speed ratio of the high temperature side cooling water pump 4a and the low temperature side cooling water pump 4b, and the rotational speed ratio of the cold water pump 5 are ratios relative to the rated operations thereof.

On the other hand, at step S3, if the calculated storage of heat is higher than or equal to the predetermined lower limit (No, at step S3), the control device 71 compares the storage of heat and an upper limit of storage of heat (step S9). If the storage of heat is smaller than the upper limit (Yes, at step S9), the control device 71 proceeds to step S5.

Namely, the control device 71 sets a load for heat storage operation as a load for the chiller load.

Further, if the storage of heat is larger than or equal to the upper limit (No, at step S9), the control device 71 determines that the load 3 can be cooled by stored heat in the thermal storage tank 8 and stops the chiller (step S10).

It is preferable that the upper limit of the storage of heat should be determined in advance as a design factor.

Further, in a similar manner as the comparison with the lower limit of the storage of heat, the control device 71 may be configured to determine that storage of heat of the thermal storage tank 8 is higher than the upper limit when the thermal storage tank temperature measured by the thermal storage tank temperature sensor 8a is lower than a

predetermined threshold. In this case, it is preferable that the upper limit of the storage of heat should have been set to the threshold value.

In addition, when cooling the load 3, the control
5 device 71 can maintain the COP of the heat source system 100 at the maximum by executing repeatedly the steps S1 to S10 with a predetermined time interval, e.g. 10 minutes, even when the wet-bulb temperature of outside air or the requirement load of the load 3 is changed.

10 According to this configuration, in a case when the storage of heat of the thermal storage tank 8 is larger than or equal to the lower limit and is smaller than the upper limit, the chiller is operated with a partial load and heat is accumulated in the thermal storage tank 8.
15 Therefore, the COP of the heat source system 100 can be kept at the maximum, and it is possible to achieve energy conservation in cooling operation.

In addition, in a case when the storage of heat (cooling amount) of the thermal storage tank 8 is smaller
20 than the lower limit, and when the requirement load of the load 3 is smaller than the operating load of the chiller, the chiller can be operated with a load factor that makes COP of the heat source system 100 maximum, and heat is accumulated in the thermal storage tank 8. Namely, COP of
25 the heat source system 100 can be kept at maximum even when the requirement load of the load 3 is small.

Further, in a case when storage of heat of the thermal storage tank 8 is smaller than the lower limit, and if a requirement load of the load 3 is larger or equal to
30 the operating load of the chiller, the chiller may be

operated with a partial load, and further optimization calculation may be executed such that the energy consumption should be minimum, thereby keeping the COP of the heat source system 100 high and achieving energy
5 conservation.

In addition, when storage of heat of the thermal storage tank 8 is larger than or equal to a predetermined upper limit, the chiller may be stopped and energy consumption can be achieved.

10 Thus, the control device 71 can be operated with a partial load keeping the COP of the heat source system 100 high and energy conservation can be achieved.

For example, even when the cooling capacity of the thermal storage tank 8 is small, COP in the operation can
15 be kept high utilizing the thermal storage tank 8 as a heat buffer. Thus energy conservation can be achieved.

Further, even when at least one of wet-bulb temperature of outside air, a requirement load of the load 3 and storage of heat of the thermal storage tank 8 is
20 changed, the control device 71 may execute optimization calculation and set a desired control value corresponding to the change. Thus the COP of the heat source system 100 can be kept high.

Alternatively, instead of executing optimization
25 calculation at step S7, the control device 71 may be configured to set a desired control value of the object to be controlled by referring to a data table which is preset based on the wet-bulb temperature of outside air, storage of heat of the thermal storage tank 8, and the requirement
30 load of the load 3 (see Fig. 1).

In other words, the control device 71 may be configured to set a desired control value of the object to be controlled based on the preset data table without executing optimization calculation at step S7.

5 In this case, it is preferable that the data table should be composed in a map format showing correspondences among wet-bulb temperature of outside air, a load factor of the chiller that is determined by a requirement load of the load 3 and storage of heat of the thermal storage tank 8,
10 and a desired control value that makes a evaluation function minimum, as shown in FIG. 6 for example.

In FIG. 6, a data table showing relations among wet-bulb temperature of outside air, a load factor of the chiller, and a rotational speed ratio of the high
15 temperature side cooling water pump 4a is shown as an example. By preparing such a data table for other objects to be controlled and desired control values thereof, the control device 71 can set desired control values of the objects to be controlled based on wet-bulb temperature of
20 outside air and a load factor of the chiller.

In addition, storage of heat of the thermal storage tank 8 can be calculated from a load of the load 3 and load factors of the chillers (high temperature side chiller 2a, low temperature side chiller 2b).

25 Further, it is preferable that optimization calculation of a desired control value for generating a data table as shown in FIG. 6 should be executed using, for example, a load factor of the cold water system.

As described above, the heat source system 100
30 according to the present embodiment can set desired control

values of the objects to be controlled (high temperature side cooling water pump 4a, low temperature side cooling water pump 4b, cold water pump 5, cooling fan 6) based on optimization calculation corresponding to changes of wet-bulb temperature of outside air and changes of a load of the load 3 during cooling operation or heat storage operation.

Note that the present embodiment can be applied to heat source systems having different configurations of a cooling water system. For example, the heat source system 100 shown in FIG. 1, in which the high temperature side chiller 2a and the low temperature side chiller 2b are arranged in parallel in the cooling water system, may be applied to the heat source system 101 shown in FIG. 7 in which the high temperature side chiller 2a and the low temperature side chiller 2b are arranged in series in the cooling water system.

In the heat source system 101 shown in FIG. 7, a high temperature side cooling water pump 4a, a high temperature side chiller 2a and a low temperature side chiller 2b are arranged in series to a cooling water outgoing flow pipe 61a which is connected to the outlet side of the cooling tower 1. Cooling water cooled by the cooling tower 1 is sent to the high temperature side chiller 2a and the low temperature side chiller 2b in sequence via the high temperature side cooling water pump 4a. The outlet side of the low temperature side chiller 2b is connected to the inlet side of the cooling tower 1 via the cooling water incoming flow pipe 62a so that cooling water flown out from the low temperature side chiller 2b would flow into cooling

tower 1. The rest of the configuration is same as that of the heat source system 100 shown in FIG. 1. In this configuration, a flow rate of cooling water in the cooling water system is determined by the rotational speed of the high temperature side cooling water pump 4a.

According to the heat source system 101 in FIG. 7, one high temperature side cooling water pump 4a is disposed in the cooling water system, and the number of pumps can be cut down compared to the heat source system 100 in FIG. 1. Therefore, the heat source system 101 can be implemented with lower cost than the heat source system 100 in FIG. 1.

As shown in FIG. 8, the present embodiment may be applied to a heat source system 102 which is provided with two cooling water systems, a high temperature side cooling water system and a low temperature side cooling water system, the high temperature side cooling water system including a high temperature side cooling tower 1a, and the low temperature side cooling water system including a low temperature side cooling tower 1b.

The high temperature side cooling tower 1a is provided with a cooling fan 6a which is driven by an inverter 51a. Cooling water flown into the high temperature side cooling tower 1a is cooled with outside air sent by the cooling fan 6a. Rotational speed of the cooling fan 6a is controlled by controlling the frequency inputted to the inverter 51a.

Further, the low temperature side cooling tower 1b is provided with a cooling fan 6b which is driven by an inverter 51b. Cooling water flown into the low temperature side cooling tower 1b is cooled with outside air sent by

the cooling fan 6b. Rotational speed of the cooling fan 6b is controlled by controlling the frequency inputted to the inverter 51b.

5 In other words, air flow rate to the high temperature side cooling tower 1a and the low temperature side cooling tower 1b is controlled with a frequency inputted to the inverters 51a and 51b.

10 The high temperature side cooling water system is provided with a high temperature side cooling water pump 4a and a high temperature side chiller 2a on a cooling water outgoing flow pipe 610a which is connected to the outlet side of the cooling tower 1a. Cooling water cooled by the high temperature side cooling tower 1a is sent to the high temperature side chiller 2a via the high temperature side cooling water pump 4a. The outlet side of the high temperature side chiller 2a is connected to the inlet side of the high temperature side cooling tower 1a via the cooling water incoming flow pipe 620a. Cooling water flown out from the high temperature side chiller 2a is flown into 20 the high temperature side cooling tower 1a.

The low temperature side cooling water system is provided with a low temperature side cooling water pump 4b and a low temperature side chiller 2b on a cooling water outgoing flow pipe 610b which is connected to the outlet 25 side of the low temperature side cooling tower 1b. Cooling water cooled by the low temperature side cooling tower 1b is sent to the low temperature side chiller 2b via the low temperature side cooling water pump 4b. The outlet side of the low temperature side chiller 2b is connected to the 30 inlet side of the low temperature side cooling tower 1b via

the cooling water incoming flow pipe 620b. Cooling water flown out from the low temperature side chiller 2b is flown into the low temperature side cooling tower 1b.

5 Similarly to the case of the heat source system 100 shown in FIG. 1, the high temperature side cooling water pump 4a is driven by the inverter 52a, and the low temperature side cooling water pump 4b is driven by the inverter 52b.

10 Further, the rotational speed of the high temperature side cooling water pump 4a and the low temperature side cooling water pump 4b is controlled with a frequency inputted to the inverters 52a and 52b respectively.

15 In other words, a flow rate of cooling water in the high temperature side cooling water system is controlled with a frequency inputted to the inverter 52a, and a flow rate of cooling water in the low temperature side cooling water system is controlled with a frequency inputted to the inverter 52b.

20 Further, a high temperature side cooling tower outlet temperature sensor 31a, which measures an outlet temperature of cooling water in the high temperature side cooling tower 1a of the high temperature side cooling water system (high temperature side cooling water temperature at the cooling tower outlet), is provided to the outlet side
25 of the high temperature side cooling tower 1a. Similarly, a low temperature side cooling tower outlet temperature sensor 31b, which measures an outlet temperature of cooling water in the low temperature side cooling tower 1b of the low temperature side cooling water system (low temperature
30 side cooling water temperature at the cooling tower outlet),

is provided to the outlet side of the low temperature side cooling tower 1b. The rest of the configuration is same as that of the heat source system 100 shown in FIG. 1.

5 In this configuration, a flow rate of cooling water in the high temperature side cooling water system is determined by the rotational speed of the high temperature side cooling water pump 4a, and a flow rate of cooling water in the low temperature side cooling water system is determined by the rotational speed of the low temperature
10 side cooling water pump 4b.

In addition, the control device 71 executes optimization calculation such that the evaluation function W shown with the formula (1) becomes minimum. The optimization calculation is executed using the following
15 parameters, a chiller load, a wet-bulb temperature of outside air, a high temperature side cooling water temperature at the cooling tower outlet, a low temperature side cooling water temperature at the cooling tower outlet, a cold water temperature of high temperature chiller outlet
20 or a air flow rate ratio of the cooling fan 6a, a cold water temperature of low temperature chiller outlet or a air flow rate ratio of the cooling fan 6b, a rotational speed ratio of the high temperature side cooling water pump 4a and the low temperature side cooling water pump 4b or a
25 flow rate ratio of cooling water, and a rotational speed ratio of cold water pump 5 or a flow rate ratio of cold water.

Thus the present embodiment can be applied to the heat source system 102 which includes two cooling towers
30 (high temperature side cooling tower 1a, low temperature

side cooling tower 1b). Namely, the present embodiment can be applied without limiting the arrangement of the high temperature side chiller 2a and the low temperature side chiller 2b and the arrangement of the cooling tower in the cooling water system. Thus the present embodiment can be widely applied.

Further, although it is not shown in the figures, the present embodiment can also be applied to a heat source system that is not provided with the thermal storage tank 8. In this case, a flow rate of cold water in the load 3 during operation would be controlled by the cold water pump 5 (see FIG. 1).

In addition, there may be modified examples of the present embodiment as follows.

For example, a flow rate and a temperature may be set as a constant (fixed value) in the optimization calculation. In this case, the control of rotational speed of the high temperature side cooling water pump 4a and the low temperature side cooling water pump 4b may be simplified. Accordingly, performance required to the inverter 52a provided to the high temperature side cooling water pump 4a and the inverter 52b provided to the low temperature side cooling water pump 4b can be lowered, and the cost may be cut down.

In addition, the chillers (high temperature side chiller 2a, low temperature side chiller 2b) may be configured as an air-cooled type heat pump chiller. In this case, energy conservation can be achieved by, optimizing a rotational speed of the cold water pump 5 and a desired value of the outlet temperature of cold water in

the chiller, and utilizing the COP characteristics of the high temperature side chiller 2a. Further, the chiller may be configured as an inverter chiller controlling a rotational speed of compressor by inverter control. By
5 using the inverter chiller, efficiency of partial load operation can be improved. In addition, configuration of chillers (combination of the high temperature side chiller 2a and the low temperature side chiller 2b) may be configured in another form such as a combination of an
10 absorption chiller and a compression chiller.

Further, another configuration may be possible in which, hot water is used instead of cold water, and a hot-water heat source (e.g. hot-and-chilled-water generator or heat pump) is used instead of the chiller. The
15 optimization calculation is executed with a load of heater operation, and the result is used as a desired control value. In this configuration, energy conservation during the heater operation can be achieved.

In addition, a type of the cooling tower 1 is not
20 limited to the present embodiment. For example, the cooling tower 1 may be configured as a direct-contact cooling tower or a closed-circuit cooling tower.

Further, in a case when heat storage operation is performed in accordance with a time schedule, a chiller
25 load used in partial load operation may be determined based on a predicted load value of the next day and the wet-bulb temperature of outside air.

As described above, the present invention can be changed in design in various forms and can be widely
30 applied.

WHAT IS CLAIMED IS:

1. A heat source system, comprising:

a cooling tower;

5 a first cold water system configured to circulate first cold water cooled by the cooling tower;

a second cold water system configured to circulate second cold water used for cooling a load component;

a plurality of chillers arranged in series to the
10 second cold water system and configured to cool the second cold water by transferring heat of the second cold water used for cooling the load component to the first cold water;

a control device that controls one or more objects to
15 be controlled, the objects to be controlled including at least one of a cooling fan configured to send outside air to the cooling tower, a first pump configured to circulate the first cold water, and a second pump configured to circulate the second cold water; and

20 a thermal storage unit configured to store the second cold water cooled by the chillers and provide the second cold water to the load component, wherein

the control device sets a desired control value of the object to be controlled such that an evaluation
25 function indicating energy consumption becomes minimum in response to change in condition of outside air and at least one of storage of heat of the thermal storage unit and a requirement load of the load component.

30 2. The heat source system according to claim 1, wherein

the control device sets a requirement load of the load component as a desired control value to be processed by the chillers when performing cooling operation for cooling the load component.

5

3. The heat source system according to claim 1 or claim 2, wherein

the control device sets a predetermined load as a desired control value to be processed by the chillers when performing heat storage operation for cooling the second cold water and storing the second cold water into the thermal storage unit.

4. The heat source system according to claim 1, wherein:
when performing cooling operation for cooling the load component,

in a case when the storage of heat is smaller than a predetermined lower limit and when the requirement load is larger than or equal to an operating load of the chillers, the control device sets the requirement load as the desired control value; and

in a case when the storage of heat is smaller than the predetermined lower limit and when the requirement load is smaller than an operating load of the chillers or the storage of heat is larger than or equal to the lower limit and smaller than a predetermined upper limit, the control device sets a predetermined load as the desired control value

5. The heat source system according to one of claims 1

to 4, wherein

the heat source system is provided with data showing correspondences among a desired control value that makes the evaluation function minimum, a condition of outside air,
5 and a operating load of the chillers.

6. The heat source system according to claim 5, wherein
the control device sets the desired control value in accordance with the data in response to change in the
10 condition of outside air and at least one of the storage of heat of the thermal storage unit and the requirement load of the load component.

7. A method for controlling a heat source system that
15 includes:

a cooling tower;

a first cold water system configured to circulate first cold water cooled by the cooling tower;

a second cold water system configured to circulate
20 second cold water cooling a load component;

a plurality of chillers arranged in series to the second cold water system and configured to cool the second cold water by transferring heat of the second cold water used for cooling the load component to the first cold
25 water;

a control device that controls one or more objects to be controlled, the objects to be controlled including at least one of a cooling fan configured to send outside air to the cooling tower, a first pump configured to circulate
30 the first cold water, and a second pump configured to circulate second cold water; and

a thermal storage unit configured to store the second cold water cooled by the chillers and provide the second cold water to the load component, the method comprising the steps of:

5 setting a desired control value of the object to be controlled such that an evaluation function indicating energy consumption becomes minimum in response to change in condition of outside air and at least one of storage of heat of the thermal storage unit and a requirement load of
10 the load component; and

 controlling the one or more objects to be controlled in accordance with the desired control value.

8. The method for controlling a heat source system
15 according to claim 7 further comprising

 setting the desired control value in accordance with data showing correspondences among a desired control value that makes the evaluation function minimum, a condition of outside air, and a operating load of the chillers.

20