

Description

Title of Invention: CONTROL SYSTEM, GEOTHERMAL HEAT UTILIZATION SYSTEM, CONTROL METHOD, AND PROGRAM

Technical Field

[0001]

The present disclosure relates to a control system, a geothermal heat utilization system, a control method, and a program.

This application claims priority based on Japanese Patent Application No. 2022-184746, filed in Japan on November 18, 2022, the contents of which are incorporated herein by reference.

Background Art

[0002]

In recent years, geothermal heat utilization systems that use heat stored in the ground have been proposed.

[0003]

As a technique related thereto, for example, Patent Document 1 discloses a geothermal heat utilization system of storing heat discharged from a building underground.

Citation List

Patent Literature

[0004]

Patent Document 1: JP 2018-071949 A

Summary of Invention

Technical Problem

[0005]

In the geothermal heat utilization system disclosed in Patent Document 1, heating stored in a heat storage tank is used as a heat source for heating a building or a heat source for hot water supply, and cooling stored in another heat storage tank is used as a heat source for cooling the building.

However, when the amount of heating stored in summer is small as in a cold district or the like for example, the stored heating may fall short in winter.

[0006]

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To solve the problem described above, a control system according to the present disclosure includes: a first mode control unit configured to control a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well and a heat storage assist facility including a waste heat recovery mechanism, a cooling tower, or an air-cooled heat pump in a first mode in which cooling stored in the cold water well is supplied to an apparatus and heating obtained from the apparatus is stored in the hot water well; and a second mode control unit configured to control the geothermal heat utilization system in, instead of the first mode, a second mode in which the cooling stored in the cold water well is supplied to the heat storage assist facility and heating obtained from the heat storage assist facility is stored in the hot water well.

A geothermal heat utilization system according to the present disclosure includes the control system, the heat source well facility, and the heat storage assist facility.

A control method according to the present disclosure includes: controlling a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well and a heat storage assist facility including a waste heat recovery mechanism, a cooling tower, or an air-cooled heat pump in a first mode in which cooling stored in the cold water well is supplied to an apparatus and heating obtained from the apparatus is stored in the hot water well; and controlling the geothermal heat utilization system in, instead of the first mode, a second mode in which the cooling stored in the cold water well is supplied to the heat storage assist facility and heating obtained from the heat storage assist facility is stored in the hot water well.

A program according to the present disclosure causes a computer to execute: controlling a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well and a heat storage assist facility including a waste heat recovery mechanism, a cooling

tower, or an air-cooled heat pump in a first mode in which cooling stored in the cold water well is supplied to an apparatus and heating obtained from the apparatus is stored in the hot water well; and controlling the geothermal heat utilization system in, instead of the first mode, a second mode in which the cooling stored in the cold water well is supplied to the heat storage assist facility and heating obtained from the heat storage assist facility is stored in the hot water well.

Advantageous Effects of Invention

10 [0011]

With the control system, the control system, the geothermal heat utilization system, the control method, and the program of the present disclosure, the heating stored is less likely to fall short.

15 Brief Description of Drawings

[0012]

FIG. 1 is a schematic view of a geothermal heat utilization system according to an embodiment of the present disclosure.

20 FIG. 2 is a system diagram of the geothermal heat utilization system according to the embodiment of the present disclosure.

FIG. 3 is a block diagram of a control system according to the embodiment of the present disclosure.

FIG. 4 is a flowchart a control method according to the embodiment of the present disclosure.

25 FIG. 5 is a diagram illustrating an operation of the geothermal heat utilization system in a first mode according to the embodiment of the present disclosure.

30 FIG. 6 is a diagram illustrating an operation of the geothermal heat utilization system in a second mode (waste heat utilization mode) according to the embodiment of the present disclosure.

FIG. 7 is a diagram illustrating an operation of the geothermal heat utilization system in a second mode (cooling tower utilization mode) according to the embodiment of the present disclosure.

35 FIG. 8 is a diagram illustrating an operation of the geothermal heat utilization system in a second mode (air-cooled heat pump utilization mode) according to the embodiment of the present disclosure.

FIG. 9 is a diagram illustrating an operation of the geothermal heat utilization system in a third mode according to the embodiment of the present disclosure.

FIG. 10 is a diagram illustrating a modification of the operation of the geothermal heat utilization system in the second mode (cooling tower utilization mode) according to the embodiment of the present disclosure.

FIG. 11 is a diagram illustrating a modification of the operation of the geothermal heat utilization system in the second mode (air-cooled heat pump utilization mode) according to the embodiment of the present disclosure.

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Description of Embodiments

[0013]

An embodiment according to the present disclosure is described below with reference to the drawings. In all drawings, the same or corresponding configurations are denoted by the same reference signs, and commonly applicable descriptions are omitted.

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[0014]

Embodiments

An embodiment of a geothermal heat utilization system according to the present disclosure will be described with reference to FIGs. 1 to 9.

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Configuration of Geothermal Heat Utilization System

As illustrated in FIGs. 1 and 2, a geothermal heat utilization system 1 includes a heat source well facility 10, a heat storage assist facility 20, a heat pump 30, a heat exchanger 40, and a control system 50.

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When an apparatus AA (example: air conditioning load) is using heating, the geothermal heat utilization system 1 uses the heating stored in a form of hot water in the heat source well facility 10 for the heating, and at the same time stores the cooling discharged from the apparatus AA in a form of cold water in the heat source well facility 10.

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When the apparatus AA is using cooling, the geothermal heat utilization system 1 uses the cooling stored in a form of cold water in the heat source well facility 10 for the cooling, and at the same time stores the heating discharged from the apparatus AA in a form of hot water in the heat source well facility 10.

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[0015]

Configuration of Heat Source Well Facility

The heat source well facility 10 includes a hot water well 11, a cold water well 12, and piping 13.

[0016]

Each of the hot water well 11 and the cold water well 12 extends from the ground into an aquifer LY. Each of the hot water well 11 and the cold water well 12 includes a casing with screen and the like, and is configured to take in groundwater in the aquifer LY and return the groundwater from the inside of each of the hot water well 11 and the cold water well 12 to the aquifer LY.

During a steady operation of the geothermal heat utilization system 1, hot water is stored in the aquifer LY around the hot water well 11, and cold water is stored in the aquifer LY around the cold water well 12.

The hot water well 11 and the cold water well 12 are separated from each other at a distance long enough to cause no mixing between the hot water and the cold water stored.

[0017]

In the geothermal heat utilization system 1, the heat source well facility 10 pumps the groundwater from one of the hot water well 11 and the cold water well 12, exchanges heat above ground for heat utilization and auxiliary heat storage, and then injects the heat-exchanged groundwater to the other one of the hot water well 11 and the cold water well 12. That is, the heat source well facility 10 includes two operation modes, a mode of pumping the groundwater from the hot water well 11 and injecting the water to the cold water well 12 and a mode of pumping the groundwater from the cold water well 12 and injecting the water to the hot water well 11.

[0018]

The piping 13 connects the hot water well 11 and the cold water well 12.

As illustrated in FIG. 1, a first end 131, which is one end of the piping 13, extends into the hot water well 11 and is immersed in the groundwater in the hot water well 11.

A second end 132, which is the other end of the piping 13, extends into the cold water well 12 and is immersed in the groundwater in the cold water well 12.

[0019]

Each of the first end 131 and the second end 132 is provided with a pump PP, a water injection valve VA, a check valve VB, and the like that are configured to pump water from the inside of each well into the piping 13 and to inject water from the inside of the piping 13 into each well.

The output from the pump PP can be changed by inverter control in response to a command from the control system 50.

[0020]

As illustrated in FIG. 2, the heat source well facility 10 further includes a rectifying unit 14, an injected water thermometer 15, and a regulating valve 16.

[0021]

5 The rectifying unit 14 is provided between the hot water well 11 and the cold water well 12 and the heat exchanger 40.

 The rectifying unit 14 is a connection circuit including check valves CV1 to CV4 and is connected to the piping 13 in the middle of the piping 13. The rectifying unit 14 rectifies the flow of water so that the water in the piping
10 13 flows toward the heat exchanger 40. Therefore, regardless of whether the water is pumped up from the hot water well 11 or the cold water well 12, the water in the piping 13 flows toward the heat exchanger 40. Here, the check valves CV1 to CV4 illustrated in FIG. 2 make water flow in the arrow direction and prevents the water from flowing in the direction opposite to the arrow
15 direction.

[0022]

 The injected water thermometer 15 is provided in the middle of the piping 13 extending from the heat exchanger 40 to the rectifying unit 14 and in the piping 13 through which water flows from the heat exchanger 40 to the
20 rectifying unit 14.

 The injected water thermometer 15 measures the temperature of water flowing from the heat exchanger 40 to the rectifying unit 14, and outputs the measurement result to the control system 50.

[0023]

25 The regulating valve 16 is provided in the middle of the piping 13 extending from the rectifying unit 14 toward the heat exchanger 40 and in the piping 13 through which water flows from the rectifying unit 14 to the heat exchanger 40.

 The regulating valve 16 adjusts the flow rate of water flowing from the rectifying unit 14 to the heat exchanger 40 in response to a command from the
30 control system 50, and controls the amount of water injected to each of the hot water well 11 and the cold water well 12.

[0024]

Configuration of Heat Exchanger

35 The heat exchanger 40 exchanges heat between water in the piping 13 and a medium on the sides of the heat pump 30 and the heat storage assist facility 20.

For example, the heat exchanger 40 exchanges heat between the groundwater which is the water pumped from the hot water well 11 and flowing inside the piping 13 as the water in the piping 13, and the medium on the sides of the heat pump 30 and the heat storage assist facility 20. The groundwater
 5 after the heat exchange flows from the heat exchanger 40 and through the piping 13 to be injected to the cold water well 12.

On the other hand, the heat exchanger 40 exchanges heat between the groundwater which is the water pumped from the cold water well 12 and flowing inside the piping 13 as the water in the piping 13, and the medium on
 10 the sides of the heat pump 30 and the heat storage assist facility 20. The groundwater after the heat exchange flows from the heat exchanger 40 and through the piping 13 to be injected to the hot water well 11.

For example, the heat exchanger 40 may be provided in the middle of the piping 13 extending above the ground.

15 [0025]

When the water having passed through the heat exchanger 40 is hot water, heat of hot water is stored in the hot water well 11.

When the water having passed through the heat exchanger 40 is cold water, heat of cold water is stored in the cold water well 12.

20 Here, "hot water" refers to water having a temperature higher than an initial underground temperature of groundwater in the aquifer LY, and "cold water" refers to water having a temperature lower than the initial underground temperature of the groundwater in the aquifer LY. For example, the initial underground temperature of the groundwater in the aquifer LY is 18°C.

25 [0026]

Configuration of Heat Pump

The heat pump 30 includes a condenser, an evaporator, a compressor, and the like, and is provided between the apparatus AA and the piping 13 via the heat exchanger 40.

30 The heat pump 30 cools or heats the medium subjected to heat exchange with water in the piping 13 by the heat exchanger 40. Thus, the heat pump 30 uses the heating or the cooling obtained from the water in the piping 13 for the apparatus AA, and stores the discharged heating or the discharged cooling discharged from the apparatus AA in the water in the piping 13 via the heat
 35 exchanger 40.

In the present embodiment, a turbo heat pump is used as the heat pump 30.

[0027]

The geothermal heat utilization system 1 further includes a plurality of switching valves 61 and a pump 62, and controls the flow of the medium flowing between the heat pump 30 and the heat exchanger 40.

5 The plurality of switching valves 61 and the pump 62 are provided between the heat pump 30 and the heat exchanger 40.
[0028]

The geothermal heat utilization system 1 further includes a pump 70 between the heat pump 30 and the apparatus AA, and causes a medium to flow between the heat pump 30 and the apparatus AA.

10 [0029]

Configuration of Heat Storage Assist Facility

The heat storage assist facility 20 heats the cold water in the piping 13 in the heat exchanger 40 through a medium to facilitate the storage of heat in the hot water well 11.

15 In the present embodiment, the heat storage assist facility 20 includes a waste heat recovery mechanism 201, a cooling tower 202, and an air-cooled heat pump 203.

[0030]

20 The waste heat recovery mechanism 201 recovers waste heat generated in each process in a factory where the apparatus AA is installed, and heats the medium of the heat storage assist facility 20.

The waste heat recovered by the waste heat recovery mechanism 201 is used for auxiliary heat storage in the hot water well 11.

[0031]

25 The cooling tower 202 has a general function of cooling the medium of the heat storage assist facility 20 by using heat of vaporization of water brought into contact with the atmosphere to be vaporized, and also has a function as a heating tower in the present embodiment. That is, the cooling tower 202 can cool the medium of the heat storage assist facility 20 in winter when the
30 temperature of the atmosphere is low, for example, and can also heat the medium of the heat storage assist facility 20 in summer when the temperature of the atmosphere is high, for example.

Therefore, the cooling tower 202 can be used not only as a facility for auxiliary cold storage in the cold water well 12 but also as a facility for
35 auxiliary heat storage in the hot water well 11. For example, the cooling tower 202 may be configured to be able to heat the medium of the heat storage assist facility 20 when the external air temperature is higher than the set water injection temperature.

[0032]

The air-cooled heat pump 203 includes a condenser, an evaporator, a compressor, and the like, and heats the medium of the heat storage assist facility 20.

5 With the air-cooled heat pump 203, the heating operation can be performed throughout the year.

 The heat obtained by heating the medium by the air-cooled heat pump 203 is used for auxiliary heat storage in the hot water well 11. On the other hand, the heat obtained by heating the medium by the air-cooled heat pump 203
10 is also used for heating in the apparatus AA.

[0033]

The heat storage assist facility 20 further includes a plurality of switching valves 204, a pump 205, a heat exchanger 206, and an outlet thermometer 207.

15 The primary side of the heat exchanger 206 is connected to the heat exchanger 40 via the pump 62 so that the medium flows between the heat exchanger 40 and the primary side.

[0034]

 The heat storage assist facility 20 can switch between a circuit in which
20 the medium flows between the heat exchanger 206 and the cooling tower 202 and a circuit in which the medium flows between the heat exchanger 206 and the waste heat recovery mechanism 201, through switching between the plurality of switching valves 204 in response to a command from the control system 50.

25 Thus, in the heat storage assist facility 20, the secondary side of the heat exchanger 206 can be connected to the cooling tower 202 or the waste heat recovery mechanism 201 to make the medium flow between the secondary side of the heat exchanger 206 and the cooling tower 202 or the waste heat recovery mechanism 201.

30 Therefore, the heat storage assist facility 20 can switch between an operation of storing the heat obtained by the cooling tower 202 in the water in the piping 13 and an operation of storing the heat obtained by the waste heat recovery mechanism 201 in the water in the piping 13 via the heat exchanger 40.

35 [0035]

 The outlet thermometer 207 is provided at the outlet of the medium flowing towards the heat exchanger 40 on the primary side of the heat exchanger 206.

[0036]

The heat storage assist facility 20 further includes a plurality of switching valves 208.

5 The air-cooled heat pump 203 is connected to the heat exchanger 40 via the plurality of switching valves 208 and the pump 62.

The heat storage assist facility 20 can switch between the plurality of switching valves 208 in response to a command from the control system 50. Thus, the heat storage assist facility 20 can switch between an operation of connecting the air-cooled heat pump 203 to the heat exchanger 40 via the pump
10 62 to make the medium flow between the air-cooled heat pump 203 and the heat exchanger 40 and an operation of disconnecting the air-cooled heat pump 203 from the heat exchanger 40 to prevent the medium from flowing between the air-cooled heat pump 203 and the heat exchanger 40.

[0037]

15 The geothermal heat utilization system 1 further includes a plurality of switching valves 80 between the air-cooled heat pump 203 and the apparatus AA. Thus, the geothermal heat utilization system 1 can switch between an operation of connecting the air-cooled heat pump 203 and the apparatus AA to make the medium flow between the air-cooled heat pump 203 and the apparatus
20 AA, and an operation of disconnecting the air-cooled heat pump 203 from the apparatus AA to prevent the medium from flowing between the air-cooled heat pump 203 and the apparatus AA.

[0038]

Configuration of Control System

25 As illustrated in FIG. 3, the control system 50 includes, as functions, a first mode control unit 511, a second mode control unit 512, a third mode control unit 513, an outlet temperature control unit 514, and an injected water temperature control unit 515.

[0039]

30 The control system 50 includes a CPU 51, a memory 52, a communication interface 53, and a recording medium 54 as a hardware configuration.

[0040]

35 The CPU 51 is a processor that operates in accordance with a program prepared in advance to provide various functions that will be described later. The function of the CPU 51 will be described later.

[0041]

The memory 52 has a memory area necessary for the operation of the CPU 51.

[0042]

5 The communication interface 53 is a connection interface for communicably connecting to another device via a communication line or the like, and is configured to transmit a command to another device and receive a response from another device.

[0043]

10 The recording medium 54 is a local recording medium provided in the housing of the control system 50, and is a mass storage device such as an HDD or an SSD.

[0044]

Next, the functions of the CPU 51 of the control system 50 will be described.

15 The CPU 51 functions as the first mode control unit 511, the second mode control unit 512, the third mode control unit 513, the outlet temperature control unit 514, and the injected water temperature control unit 515 as described above by operating in accordance with a program prepared in advance.

20 [0045]

The first mode control unit 511 controls the geothermal heat utilization system 1 in the first mode.

The first mode is a mode executed mainly in summer and is a mode in which cooling stored in the cold water well 12 is supplied to the apparatus AA and heating obtained from the apparatus AA is stored in the hot water well 11.

25

[0046]

The second mode control unit 512 controls the geothermal heat utilization system 1 in the second mode instead of the first mode.

The second mode is a mode in which the cooling stored in the cold water well 12 is supplied to the heat storage assist facility 20 and the heating obtained from the heat storage assist facility 20 is stored in the hot water well 11.

30

For example, the second mode control unit 512 controls the geothermal heat utilization system 1 in the second mode in summer.

35 [0047]

The third mode control unit 513 controls the geothermal heat utilization system 1 in the third mode.

The third mode is a mode used mainly in winter, in which the heating stored in the hot water well 11 is supplied to the apparatus AA and the cooling obtained from the apparatus AA is stored in the cold water well 12.

[0048]

5 The outlet temperature control unit 514 controls the geothermal heat utilization system 1 to make constant the temperature of the medium measured by the outlet thermometer 207 as the temperature of the medium at the outlet of the heat storage assist facility 20.

[0049]

10 The injected water temperature control unit 515 controls the geothermal heat utilization system 1 to make constant the injected water temperature measured by the injected water thermometer 15 as the temperature of the water injected to the hot water well 11 or the cold water well 12.

[0050]

15 Operation of Control System

An operation of the control system 50 of the present embodiment will be described below.

The operation of the control system 50 corresponds to an embodiment of the control method.

20 The control system 50 performs each step illustrated in FIG. 4.

[0051]

First, the first mode control unit 511 controls the geothermal heat utilization system 1 in the first mode (ST01: first mode control step).

The first mode is used mainly in summer.

25 The first mode corresponds to the operation performed when cooling is used in the apparatus AA.

In the first mode, the first mode control unit 511 issues a command to make the pump PP of the cold water well 12 operate and issues a command to make the water injection valve VA of the hot water well 11 open. Furthermore,
30 in the first mode, the first mode control unit 511 switches the switching valves 61, 204, and 208 to make the medium flow to the apparatus AA and prevent the medium from flowing to the heat storage assist facility 20.

Thus, as illustrated in FIG. 5, the geothermal heat utilization system 1 pumps the cold water stored in the cold water well 12 into the piping 13 and
35 supplies the cold water to the heat exchanger 40, thereby cooling the medium on the heat pump 30 side. The cooled medium functions as a refrigerant for cooling in the apparatus AA.

On the other hand, the cold water supplied to the heat exchanger 40 turns into hot water when the medium on the heat pump 30 side is cooled, is discharged toward the hot water well 11 through the piping 13, and is injected to the hot water well 11. Thus, the hot water is stored in the hot water well 11.

5 Further, the injected water temperature control unit 515 performs inverter control on the pump PP of the cold water well 12, control on the regulating valve 16, and the like, to make constant the temperature of the water injected to the hot water well 11.

[0052]

10 After ST01, the second mode control unit 512 controls the geothermal heat utilization system 1 in the second mode instead of the first mode (ST02: second mode control step).

For example, the second mode is used in summer. In this case, the second mode control unit 512 detects summer by acquiring the date, the average temperature of the external air, the input by an operator, and the like, and controls the geothermal heat utilization system 1 in the second mode in summer.

The second mode is a mode used when it is predicted that hot water will run short in winter, as in a cold district or the like, and is an operation for storing hot water in the hot water well 11 separately from the first mode by heating cold water pumped from the cold water well 12 by the heat storage assist facility 20 in summer to prepare for winter, for example.

In the second mode, the second mode control unit 512 issues a command to operate the pump PP of the cold water well 12 and issues a command to open the water injection valve VA of the hot water well 11. Furthermore, in the second mode, the second mode control unit 512 issues a command to the switching valves 61, 204, and 208 to make the medium flow to the heat storage assist facility 20 and prevent the medium from flowing to the apparatus AA.

Thus, the geothermal heat utilization system 1 pumps the cold water stored in the cold water well 12 into the piping 13 and supplies the cold water to the heat exchanger 40. On the other hand, as illustrated in FIGs. 6 to 8, the medium heated by the heat storage assist facility 20 is supplied to the heat exchanger 40 on the side of the heat storage assist facility 20, and the cold water supplied from the cold water well 12 to the heat exchanger 40 is heated to be hot water. The heated hot water is discharged toward the hot water well 11 through the piping 13 and injected to the hot water well 11. Thus, hot water in addition to the hot water stored in the first mode is stored in the hot water well 11.

[0053]

When ST02 is performed, the outlet temperature control unit 514 controls the geothermal heat utilization system 1 to make constant the temperature of the media at the outlet of the heat storage assist facility 20, and the injected water temperature control unit 515 controls the geothermal heat utilization system 1 to make constant the temperature of water injected to the hot water well 11.

When ST02 is performed, the control system 50 automatically switches the operation mode of the geothermal heat utilization system 1 to any one of the waste heat utilization mode, the cooling tower utilization mode, and the air-cooled heat pump utilization mode described below in consideration of a cooling/heating load on the apparatus AA, an external air temperature, and the like.

[0054]

Waste Heat Utilization Mode

When waste heat is generated in each process in a factory in which the apparatus AA is installed, the control system 50 operates the geothermal heat utilization system 1 in the waste heat utilization mode which is a mode in which heat is stored in the hot water well 11 by using the waste heat.

In the waste heat utilization mode, the injected water temperature control unit 515 performs inverter control on the pump PP of the cold water well 12 to make constant the temperature of the water injected to the hot water well 11, and at the same time, performs bypass control so that the heat obtained by the waste heat recovery mechanism 201 can be stored in the water in the piping 13. Specifically, as illustrated in FIG. 6, the injected water temperature control unit 515 performs bypass control of issuing a command to the switching valves 204 to make the medium flow between the waste heat recovery mechanism 201 and the heat exchanger 206, and at the same time performs inverter control on the pump 205 and control on the regulating valve 16 to make constant the temperature of the medium at the outlet of the heat storage assist facility 20.

[0055]

Cooling Tower Utilization Mode

When waste heat is not generated in each process in the factory in which the apparatus AA is installed or is generated but is insufficient, the control system 50 operates the geothermal heat utilization system 1 in the cooling tower utilization mode which is a mode in which the cooling tower 202 is operated to store heat in the hot water well 11. The operation condition in this

mode is applied when the external air wet-bulb temperature is higher than the set water injection temperature.

In the cooling tower utilization mode, the injected water temperature control unit 515 performs inverter control on the pump PP of the cold water well 12 to make constant the temperature of the water injected to the hot water well 11, and at the same time, performs bypass control so that the heat obtained by the cooling tower 202 can be stored in the water in the piping 13.

Specifically, as illustrated in FIG. 7, the injected water temperature control unit 515 performs bypass control of issuing a command to the switching valves 204 to make the medium flow between the cooling tower 202 and the heat exchanger 206, and at the same time performs inverter control on the pump 205 and control on the regulating valve 16 to make constant the temperature of the medium at the outlet of the heat storage assist facility 20. [0056]

15 Air-Cooled Heat Pump Utilization Mode

When the hot water for heating falls short in winter only with the waste heat utilization mode and the cooling tower utilization mode, the control system 50 operates the geothermal heat utilization system 1 in the air-cooled heat pump utilization mode that is a mode in which heat is stored in the hot water well 11 by operating the air-cooled heat pump 203. In this case, the injected water temperature control unit 515 issues a command to the switching valves 208 to make the medium flow between the air-cooled heat pump 203 and the heat exchanger 40 as illustrated in FIG. 8.

A feature of this mode is that heat of hot water can be stored any time when necessary, the air-cooled heat pump 203 has a high coefficient of performance (COP) because the heating operation is performed in summer, and the COP of the entire system can be improved. [0057]

When ST02 ends, ST01 is performed again, and thereafter, ST01 and ST02 are repeated during summer for example. [0058]

After ST01 and ST02, the third mode control unit 513 controls the geothermal heat utilization system 1 in the third mode (third mode control step: ST03).

35 The third mode is performed mainly in winter.

The third mode corresponds to the operation performed when the heating is used in the apparatus AA.

In the third mode, the third mode control unit 513 issues a command to operate the pump PP of the hot water well 11 and issues a command to open the water injection valve VA of the cold water well 12. Furthermore, in the third mode, the third mode control unit 513 issues a command to the switching
 5 valves 61, 204, and 208 to make the medium flow to the apparatus AA and prevent the medium from flowing to the heat storage assist facility 20.

Accordingly, as illustrated in FIG. 9, in the geothermal heat utilization system 1, hot water stored in the hot water well 11 is pumped into the piping 13 and supplied to the heat exchanger 40 to heat the medium on the side of the
 10 heat pump 30, and the heated medium functions as a heating medium for heating in the apparatus AA. On the other hand, the hot water supplied to the heat exchanger 40 turns into cold water by heating the medium on the side of the heat pump 30, is discharged toward the cold water well 12 through the piping 13, and is injected to the cold water well 12. Thus, cold water is stored
 15 in the cold water well 12.

In ST03, the injected water temperature control unit 515 performs inverter control on the pump PP of the hot water well 11, control on the regulating valve 16, and the like, to make constant the temperature of the water injected to the cold water well 12.

20 [0059]

In the third mode, when the hot water stored in the hot water well 11 falls short, the geothermal heat utilization system 1 switches between the plurality of switching valves 80 to connect the air-cooled heat pump 203 and the apparatus AA to make the medium flow between the apparatus AA and the
 25 air-cooled heat pump 203, and uses the air-cooled heat pump 203 for heating in the apparatus AA.

[0060]

Operational Effects

In the present embodiment, the control system 50 allows the heating
 30 obtained from the heat storage assist facility 20 in addition to the heating obtained from the apparatus AA to be stored in the hot water well 11.

Therefore, the stored heating is unlikely to fall short.

[0061]

According to the present embodiment, the waste heat recovery
 35 mechanism 201 recovers the waste heat from the factory, whereby the waste heat can be effectively used.

Therefore, the environmental burden is reduced.

[0062]

The control system 50 according to the present embodiment can perform control to make constant the temperature of the medium at the outlet of the heat storage assist facility 20.

Therefore, the heat storage assist facility 20 can stably assist the heat storage in the hot water well 11.
[0063]

With the control system 50 according to the present embodiment, the temperature of the water injected to the hot water well 11 can be made constant, whereby the temperature of the hot water well 11 can be kept constant.
[0064]

According to the present embodiment, the control system 50 performs control in the second mode in summer so that heating obtained from the heat storage assist facility 20 in summer can be stored in the hot water well 11.
Therefore, the geothermal heat utilization system 1 facilitates storage of heating even in a cold district and can continuously utilize geothermal heat.
[0065]

In general, a geothermal heat utilization system using an aquifer needs to maintain annual heat amount balance and pumped water/returned water volume balance for a long-term operation.

Simple use of geothermal heat without considering the difference in air conditioning load (heat amount) between summer and winter leads to heat amount imbalance or volume imbalance between cold water and hot water.

As a result, the heat storage mass of the waste cold or the waste heat continues to expand, meaning that the geothermal heat cannot be efficiently used. Furthermore, the underground environment might even be adversely affected.

For example, in the case where the cooling load in summer is larger than the heating load in winter as in western Japan, it is possible to maintain the balance between heat and substance by cold storage in a refrigeration unit or cold storage in a cooling tower in addition to normal operation in winter.

However, when the heating load in winter overwhelms the cooling load in summer as in east Japan, a heat amount of hot water needs to be stored in summer due to an excessive amount of stored cooling.

As described above, when no means for storing the heat amount of hot water in summer is considered, introducing a geothermal heat utilization system may be difficult in a cold district.

As a comparative example, there is an example, in the Netherlands, in which the geothermal heat utilization system is used in accordance with the cooling load. However, in a cold region such as Hokkaido, the geothermal heat utilization system cannot be used in a region where the summer cooling load is small.

In view of this, according to the control system 50 of the present embodiment, since the heating obtained from the heat storage assist facility 20 in summer can be stored in the hot water well 11, introduction of the geothermal heat utilization system 1 to a cold district is facilitated.

[0066]

According to the present embodiment, heat exchange is performed between the water in the piping 13 and the medium on the sides of the apparatus AA and the heat storage assist facility 20, whereby heat collection between the heat source well facility 10 and the apparatus AA and between the heat source well facility 10 and the heat storage assist facility 20 is facilitated.

[0067]

According to the present embodiment, since the heat storage assist facility 20 includes the cooling tower 202, it is possible to effectively use natural energy, realize energy saving, and contribute to carbon neutral.

[0068]

Further, according to the present embodiment, since the heat storage assist facility 20 includes the waste heat recovery mechanism 201, the cooling tower 202, and the air-cooled heat pump 203, it is possible to establish a system in accordance with the use by the user.

[0069]

Modifications

In the above-described embodiment, the second mode control unit 512 controls the geothermal heat utilization system 1 in the second mode in summer. Still, the geothermal heat utilization system 1 may be controlled in any manner as long as heating obtained from the heat storage assist facility 20 can be stored in the hot water well 11.

As a first modification, the second mode control unit 512 may control the geothermal heat utilization system 1 in the second mode in summer and in a season other than summer, that is, spring, autumn, or winter.

As a second modification, the second mode control unit 512 may control the geothermal heat utilization system 1 in the second mode regardless of the season.

As a third modification, the second mode control unit 512 may perform control in the second mode when the external air temperature is higher than the set water injection temperature.

[0070]

5 In the above-described embodiment, the heat storage assist facility 20 includes the waste heat recovery mechanism 201, the cooling tower 202, and the air-cooled heat pump 203. Still, any configuration may be employed as long as the heat storage in the hot water well 11 can be assisted.

10 As a modification, the heat storage assist facility 20 may include the waste heat recovery mechanism 201 and the cooling tower 202, and may not include the air-cooled heat pump 203.

 As another modification, the heat storage assist facility 20 may include at least one of the waste heat recovery mechanism 201, the cooling tower 202, and the air-cooled heat pump 203.

15 [0071]

 In the above-described embodiment, in the cooling tower utilization mode in ST02, the heat storage assist facility 20 utilizes only the cooling tower 202 among the waste heat recovery mechanism 201, the cooling tower 202, and the air-cooled heat pump 203. However, the heat storage assist facility 20 may be utilized in any manner as long as the heat storage in the hot water well 11 can be assisted. As a modification, in the cooling tower utilization mode, the heat storage assist facility 20 may simultaneously utilize the waste heat recovery mechanism 201 and the cooling tower 202. For example, as illustrated in FIG. 10, the injected water temperature control unit 515 may perform bypass control to make the medium flow between the cooling tower 202 and the heat exchanger 206 and between the waste heat recovery mechanism 201 and the heat exchanger 206. Thus, the heat storage assist facility 20 can use the waste heat recovery mechanism 201 and the cooling tower 202 simultaneously, that is, in parallel.

30 [0072]

 In the above-described embodiment, among the waste heat recovery mechanism 201, the cooling tower 202, and the air-cooled heat pump 203, only the air-cooled heat pump 203 is used in the air-cooled heat pump utilization mode in ST02. Still, the air-cooled heat pump may be used in any manner as long as the heat storage in the hot water well 11 can be assisted. As a modification, in the air-cooled heat pump utilization mode, the heat storage assist facility 20 may simultaneously utilize the waste heat recovery mechanism 201, the cooling tower 202, and the air-cooled heat pump 203. For example, as

illustrated in FIG. 11, the control system 50 may perform bypass control to make the medium flow between the air-cooled heat pump 203 and the heat exchanger 40, between the cooling tower 202 and the heat exchanger 206, and between the waste heat recovery mechanism 201 and the heat exchanger 206.

5 Thus, the heat storage assist facility 20 can use the waste heat recovery mechanism 201, the cooling tower 202, and the air-cooled heat pump 203 simultaneously, that is, in parallel.

[0073]

In the embodiments described above, the various processes are
10 implemented by a program for achieving the various functions of the control system 50, the program being stored in a computer-readable recording medium, and the program stored in the recording medium being read and executed by a computer system. Here, the procedure of the various processing of the CPU 51 of the computer system is stored in the computer-readable recording medium in
15 the form of a program, and the various processing is performed by reading and executing that program by the computer. The computer-readable recording medium refers to a magnetic disk, a magneto-optical disk, a CD-ROM, a DVD-ROM, a semiconductor memory, and the like. The computer program may be distributed to a computer via a communication line and the like, and the
20 computer having received the distribution may execute the program.

[0074]

Other Embodiments

While the embodiments of the present disclosure are described above, the embodiments are examples, and are not intended to limit the scope of the
25 present disclosure. The embodiments can be implemented in various other forms, and various omissions, substitutions, and modifications can be made without departing from the gist of the present disclosure. The embodiments and variations thereof are included in the scope of the present disclosure and equivalents thereof as well as in the scope and gist of the present disclosure.

30 [0075]

Supplementary Notes

The control system 50, the geothermal heat utilization system 1, the control method, and the program according to the embodiment are understood as follows, for example.

35 [0076]

(1) The control system 50 according to a first aspect includes: the first mode control unit 511 configured to control the geothermal heat utilization system 1 including the heat source well facility 10 including the hot water well

11 and the cold water well 12 and the heat storage assist facility 20 including the waste heat recovery mechanism 201, the cooling tower 202, or the air-cooled heat pump 203 in the first mode in which cooling stored in the cold water well 12 is supplied to the apparatus AA and heating obtained from the apparatus AA is stored in the hot water well 11; and the second mode control unit 512 configured to control the geothermal heat utilization system 1 in, instead of the first mode, the second mode in which the cooling stored in the cold water well 12 is supplied to the heat storage assist facility 20 and heating obtained from the heat storage assist facility 20 is stored in the hot water well 11.

[0077]

In this aspect, the control system 50 allows the heating obtained from the heat storage assist facility 20 in addition to the heating obtained from the apparatus AA to be stored in the hot water well 11.

Therefore, the stored heating is unlikely to fall short.

[0078]

(2) The control system 50 according to a second aspect is the control system 50 according to (1), wherein the waste heat recovery mechanism 201 recovers waste heat from a factory.

[0079]

This aspect allows the waste heat recovery mechanism 201 to effectively use the waste heat.

Therefore, the environmental burden is reduced.

[0080]

(3) The control system 50 according to a third aspect is the control system 50 according to (1) or (2) further including the outlet temperature control unit 514 configured to control the geothermal heat utilization system 1 to make constant a temperature of a medium at an outlet of the heat storage assist facility 20.

[0081]

In this aspect, the control system 50 can control the temperature of the medium at the outlet of the heat storage assist facility 20 to be constant.

Therefore, the heat storage assist facility 20 can stably assist the heat storage in the hot water well 11.

[0082]

(4) The control system 50 according to a fourth aspect is the control system 50 according to any one of (1) to (3) further including the injected water temperature control unit 515 configured to control the geothermal heat

utilization system 1 to make constant a temperature of water injected to the hot water well 11.

[0083]

In this aspect, the control system 50 can control the temperature of the water injected to the hot water well 11 to be constant, making the temperature of the hot water well 11 constant.

[0084]

(5) The control system 50 according to a fifth aspect is the control system 50 according to any one of (1) to (4), wherein the second mode control unit 512 controls the geothermal heat utilization system in the second mode in summer.

[0085]

In this aspect, the control system 50 allows the heating obtained from the heat storage assist facility 20 to be stored in the hot water well 11 in summer.

Therefore, the geothermal heat utilization system 1 facilitates storage of heating even in a cold district and can continuously utilize geothermal heat.

[0086]

(6) The control system 50 according to a sixth aspect is the control system 50 according to any one of (1) to (5), wherein the heat source well facility 10 further includes the piping 13 connecting the hot water well 11 and the cold water well 12 and the heat exchanger 40 configured to exchange heat between water in the piping 13 and the medium on the sides of the apparatus AA and the heat storage assist facility 20.

[0087]

In this aspect, heat is exchanged between the water in the piping 13 and the medium on the sides of the apparatus AA and the heat storage assist facility 20, whereby heat collection between the heat source well facility 10 and the apparatus AA and between the heat source well facility 10 and the heat storage assist facility 20 is facilitated.

[0088]

(7) The geothermal heat utilization system 1 according to a seventh aspect includes: the control system 50 according to any one of (1) to (6); the heat source well facility 10; and the heat storage assist facility 20.

[0089]

In this aspect, the geothermal heat utilization system 1 can store the heating obtained from the heat storage assist facility 20 in addition to the heating obtained from the apparatus AA to be stored in the hot water well 11.

Therefore, the stored heating is unlikely to fall short.

[0090]

(8) A control method according to an eighth aspect includes: controlling the geothermal heat utilization system 1 including the heat source well facility 10 including the hot water well 11 and the cold water well 12 and the heat storage assist facility 20 including the waste heat recovery mechanism 201, the cooling tower 202, or the air-cooled heat pump 203 in the first mode in which cooling stored in the cold water well 12 is supplied to the apparatus AA and heating obtained from the apparatus AA is stored in the hot water well 11; and controlling the geothermal heat utilization system 1 in, instead of the first mode, the second mode in which the cooling stored in the cold water well 12 is supplied to the heat storage assist facility 20 and heating obtained from the heat storage assist facility 20 is stored in the hot water well 11.

[0091]

In this aspect, the control method allows the heating obtained from the heat storage assist facility 20 in addition to the heating obtained from the apparatus AA to be stored in the hot water well 11.

Therefore, the stored heating is unlikely to fall short.

[0092]

(9) A program according to a ninth aspect causes a computer to execute: controlling the geothermal heat utilization system 1 including the heat source well facility 10 including the hot water well 11 and the cold water well 12 and the heat storage assist facility 20 including the waste heat recovery mechanism 201, the cooling tower 202, or the air-cooled heat pump 203 in the first mode in which cooling stored in the cold water well 12 is supplied to the apparatus AA and heating obtained from the apparatus AA is stored in the hot water well 11; and controlling the geothermal heat utilization system 1 in, instead of the first mode, the second mode in which the cooling stored in the cold water well 12 is supplied to the heat storage assist facility 20 and heating obtained from the heat storage assist facility 20 is stored in the hot water well 11.

[0093]

In this aspect, the program allows the heating obtained from the heat storage assist facility 20 in addition to the heating obtained from the apparatus AA to be stored in the hot water well 11.

Therefore, the stored heating is unlikely to fall short.

Industrial Applicability

[0094]

According to the aspect described above, the stored heating is less likely to fall short.

Reference Signs List

- | | |
|----|--------------------------------------|
| 5 | [0095] |
| | 1 Geothermal heat utilization system |
| | 11 Hot water well |
| | 12 Cold water well |
| | 13 Piping |
| 10 | 14 Rectifying unit |
| | 15 Injected water thermometer |
| | 16 Regulating valve |
| | 20 Heat storage assist apparatus |
| | 30 Heat pump |
| 15 | 40 Heat exchanger |
| | 50 Control system |
| | 51 CPU |
| | 52 Memory |
| | 53 Communication interface |
| 20 | 54 Recording medium |
| | 61 Switching valve |
| | 62 Pump |
| | 70 Pump |
| | 80 Switching valve |
| 25 | 131 First end |
| | 132 Second end |
| | 201 Waste heat recovery mechanism |
| | 202 Cooling tower |
| | 203 Air-cooled heat pump |
| 30 | 204 Switching valve |
| | 205 Pump |
| | 206 Heat exchanger |
| | 207 Outlet thermometer |
| | 208 Switching valve |
| 35 | 511 First mode control unit |
| | 512 Second mode control unit |
| | 513 Third mode control unit |
| | 514 Outlet temperature control unit |

- 515 Injected water temperature control unit
- AA Apparatus
- CV1 Check valve
- CV2 Check valve
- 5 CV3 Check valve
- CV4 Check valve
- LY Aquifer
- PP PUMP
- VA Water injection valve
- 10 VB Check valve

Claims

[Claim 1]

A control system, comprising:

a first mode control unit configured to control a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well and a heat storage assist facility including a waste heat recovery mechanism, a cooling tower, or an air-cooled heat pump in a first mode in which cooling stored in the cold water well is supplied to an apparatus and heating obtained from the apparatus is stored in the hot water well; and

a second mode control unit configured to control the geothermal heat utilization system in, instead of the first mode, a second mode in which the cooling stored in the cold water well is supplied to the heat storage assist facility and heating obtained from the heat storage assist facility is stored in the hot water well.

[Claim 2]

The control system according to claim 1, wherein the waste heat recovery mechanism recovers waste heat from a factory.

[Claim 3]

The control system according to claim 1 or 2, further comprising an outlet temperature control unit configured to control the geothermal heat utilization system to make constant a temperature of a medium at an outlet of the heat storage assist facility.

[Claim 4]

The control system according to claim 1 or 2, further comprising an injected water temperature control unit configured to control the geothermal heat utilization system to make constant a temperature of water injected to the hot water well.

[Claim 5]

The control system according to claim 1 or 2, wherein the second mode control unit controls the geothermal heat utilization system in the second mode in summer.

[Claim 6]

The control system according to claim 1 or 2, wherein the heat source well facility further includes piping connecting the hot water well and the cold water well and a heat exchanger configured to exchange heat between water in the piping and a medium on sides of the apparatus and the heat storage assist facility.

[Claim 7]

A geothermal heat utilization system, comprising:
the control system according to claim 1 or 2;
the heat source well facility; and
the heat storage assist facility.

[Claim 8]

A control method, comprising:
controlling a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well and a heat storage assist facility including a waste heat recovery mechanism, a cooling tower, or an air-cooled heat pump in a first mode in which cooling stored in the cold water well is supplied to an apparatus and heating obtained from the apparatus is stored in the hot water well; and
controlling the geothermal heat utilization system in, instead of the first mode, a second mode in which the cooling stored in the cold water well is supplied to the heat storage assist facility and heating obtained from the heat storage assist facility is stored in the hot water well.

[Claim 9]

A program causing a computer to execute:
controlling a geothermal heat utilization system including a heat source well facility including a hot water well and a cold water well and a heat storage assist facility including a waste heat recovery mechanism, a cooling tower, or an air-cooled heat pump in a first mode in which cooling stored in the cold water well is supplied to an apparatus and heating obtained from the apparatus is stored in the hot water well; and
controlling the geothermal heat utilization system in, instead of the first mode, a second mode in which the cooling stored in the cold water well is supplied to the heat storage assist facility and heating obtained from the heat storage assist facility is stored in the hot water well.