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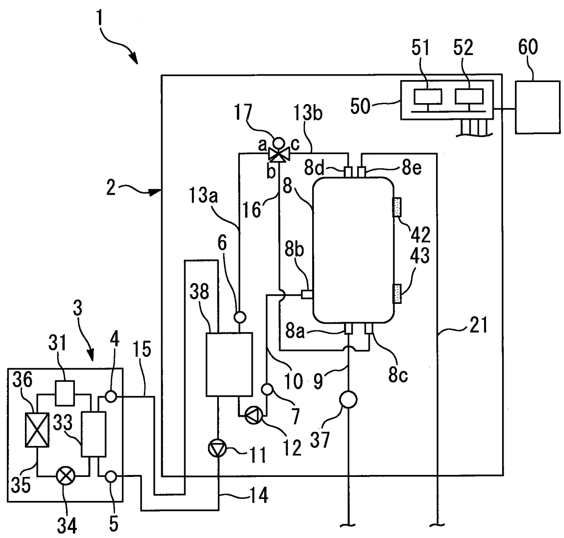
(54) **STORAGE TYPE HOT WATER SUPPLYING SYSTEM**

(57) A storage type hot water supplying system 1 includes: a heat exchanger 38 configured to exchange heat between a heating medium and water; a storage hot water tank 8; a first pump 11 configured to circulate the heating medium in a first circuit connecting the heat exchanger 38 and a heat pump device 3 to each other; a second pump 12 configured to circulate the water in a second circuit connecting the heat exchanger 38 and the hot water storage tank 8 to each other; and a control device 50 configured to control the first pump and the second pump. In a heat accumulating operation in which the hot water is accumulated in the hot water storage tank 8, the first pump 11 is controlled so that the temperature of the heating medium heated by the heat pump device 3 becomes equal to a target temperature, and the second pump 12 is controlled so that a water temperature difference that is the difference between the temperature of the hot water heated in the heat exchanger 38 and the temperature of the water before being heated in the heat exchanger 38 becomes equal to a heating medium temperature difference that is the difference between the temperature of the heating medium heated by the heat pump device 3 and the temperature of the heating medium before being heated by the heat pump device 3.

FIG. 1



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Description

[Technical Field]

[0001] The present invention relates to a storage type hot water supplying system.

[Background Art]

[0002] A known storage type hot water supplying system includes a heat pump configured to heat a heating medium, a heat exchanger configured to exchange heat between the heated heating medium and water, and a hot water storage tank configured to store the heated hot water (for example, see PTL 1).

[0003] In the system disclosed in PTL 1, the rotational speed of a first pump (13) is adjusted so that the temperature of a heating medium flowing out of a first heat exchanger (11) of the heat pump becomes equal to a first temperature higher than a heat storage temperature set in advance. The rotational speed of a second pump (22) is adjusted so that the temperature of hot water flowing out of a second heat exchanger (16) becomes equal to the abovementioned heat storage temperature.

[Citation List]

[Patent Literature]

[0004] [PTL 1] Japanese Unexamined Patent Application Publication No. 2013-36648

[Summary of Invention]

[Technical Problem]

[0005] The heat exchange capacity of the heat exchanger configured to exchange heat between the heating medium and the water decreases over time. This is due to the deposition of scale, for example. The conventional system described above has the following problem. When the heat exchange capacity of the second heat exchanger (16) decreases over time, the temperature of the hot water flowing out of the second heat exchanger (16) decreases if the circulation flow rate of the water remains constant. In order to maintain the temperature of the hot water flowing out of the second heat exchanger (16), the rotational speed of the second pump (22) is reduced, and the circulation flow rate of the water decreases. When the circulation flow rate of the water decreases, the temperature of the heating medium returning from the second heat exchanger (16) to the first heat exchanger (11) of the heat pump rises. The rise in the temperature of the heating medium flowing into the first heat exchanger (11) of the heat pump degrades energy efficiency, for example, decreases the coefficient of performance.

[0006] The present invention has been made in order to solve the abovementioned problem, and an object thereof is to provide a storage type hot water supplying system capable of reducing the degradation in energy efficiency even when the heat exchange capacity of the heat exchanger decreases over time.

[Solution to Problem]

[0007] A storage type hot water supplying system according to the present invention includes: heating means for heating a heating medium; a heat exchanger configured to exchange heat between the heating medium and water; a hot water storage tank configured to store hot water heated in the heat exchanger; a first pump configured to circulate the heating medium in a first circuit connecting the heat exchanger and the heating means to each other; a second pump configured to circulate water in a second circuit connecting the heat exchanger and the hot water storage tank to each other; and control means for controlling the first pump and the second pump. In a heat accumulating operation for accumulating hot water in the hot water storage tank, the first pump is controlled so that a temperature of the heating medium heated by the heating means becomes equal to a target temperature, and the second pump is controlled so that a water temperature difference that is a difference between a temperature of the hot water heated in the heat exchanger and a temperature of the water before being heated in the heat exchanger becomes equal to a heating medium temperature difference that is a difference between the temperature of the heating medium heated by the heating means and a temperature of the heating medium before being heated by the heating means.

[Advantageous Effects of Invention]

[0008] According to the storage type hot water supplying system of the present invention, the degradation in the energy efficiency can be reduced even when the heat exchange capacity of the heat exchanger decreases over time.

[Brief Description of Drawings]

[0009]

Fig. 1 illustrates a storage type hot water supplying system of a first embodiment.
Fig. 2 illustrates a storage type hot water supplying system of a second embodiment.

[Description of Embodiments]

[0010] Embodiments are described below with reference to the drawings. Common elements in the drawings are denoted by the same symbols, and overlapping descriptions are simplified or omitted.

First embodiment

[0011] Fig. 1 illustrates a storage type hot water supplying system of a first embodiment. As illustrated in Fig. 1, a storage type hot water supplying system 1 of this embodiment includes a tank unit 2, a heat pump device 3, a control device 50, and a remote controller 60. The tank unit 2 includes a hot water storage tank 8. The heat pump device 3 is an example of heating means for heating a heating medium. The control device 50 is an example of control means for controlling the operation of the storage type hot water supplying system 1. The remote controller 60 is an example of a user interface. The remote controller 60 can receive user operation such as a command for operation and the change of set values.

[0012] The tank unit 2 and the heat pump device 3 are connected to each other via a conduit 14, a conduit 15, and electric wiring (not shown). The tank unit 2 may be placed indoors or may be placed outdoors. The heat pump device 3 may be placed outdoors. The remote controller 60 may be installed in a room.

[0013] In this embodiment, the control device 50 is installed in the tank unit 2. Various kinds of actuators such as a valve, a pump, and a compressor and various kinds of sensors included in the storage type hot water supplying system 1 are electrically connected to the control device 50. The remote controller 60 is connected to the control device 50 through wired or wireless connection such that bi-directional data communication is possible. Although not shown, the remote controller 60 may include a display configured to display information such as the state of the storage type hot water supplying system 1, an operation unit such as a button to be operated by a user, and a voice output device configured to provide voice guide.

[0014] The heat pump device 3 includes a refrigerant circuit. The refrigerant circuit includes a compressor 31, a heat exchanger 33, a decompression device 34, an evaporator 36, and a refrigerant pipe 35 annularly connecting those elements to each other. The heat exchanger 33 exchanges heat between a high-pressure and high-temperature refrigerant compressed by the compressor 31 and a liquid heating medium. The heating medium may be water or may be brine other than water such as calcium chloride solution, ethylene glycol solution, and alcohol. The decompression device 34 expands and decompress the high-pressure refrigerant that has passed through the heat exchanger 33. The decompression device 34 may be an expansion valve capable of changing the opening degree thereof. The evaporator 36 evaporates the low-pressure refrigerant that has passed through the decompression device 34. The fluid of which heat is exchanged with the refrigerant in the evaporator 36 may be air, ground water, waste water, or solar water, for example. The heat pump device 3 may include a fan or a pump (not shown) configured to send the fluid to the evaporator 36.

[0015] The heat pump device 3 may be able to change the heating power [kW]. The heating power is a quantity of heat provided to the heating medium by the heat pump device 3 per unit of time. The control device 50 may change the heating power of the heat pump device 3 by changing the capacity of the compressor 31. The control device 50 may change the capacity of the compressor 31 by changing the rotational speed of the compressor 31. The control device 50 may change the rotational speed of the compressor 31 by inverter control, for example.

[0016] The hot water storage tank 8 stores hot water heated by the heat pump device 3. The hot water storage tank 8 is covered by a heat insulating material (not shown). Thermal stratification in which the temperature of the upper layer is high and the temperature of the lower layer is low can be formed in the hot water storage tank 8 due to the density difference in water depending on the temperature. An inlet 8a provided in the lower portion of the hot water storage tank 8 is connected to a water supply pipe 9. Water supplied from a water source such as water supply is decompressed to a predetermined pressure by a decompression valve 37, and flows into the hot water storage tank 8 from the inlet 8a through the water supply pipe 9.

[0017] An outlet 8e provided in the upper portion of the hot water storage tank 8 is connected to a hot water supply pipe 21. The hot water stored in the hot water storage tank 8 flows from the outlet 8e, and is supplied to the outside of the storage type hot water supplying system 1 through the hot water supply pipe 21. The hot water storage tank 8 is maintained in a full state by causing the same amount of water as the hot water that has flowed out to the hot water supply pipe 21 to flow into the hot water storage tank 8 from the water supply pipe 9.

[0018] A plurality of tank temperature sensors 42 and 43 are mounted on the hot water storage tank 8 in positions at different heights. The volume of the hot water and the heat storage amount in the hot water storage tank 8 can be detected by detecting the temperature distribution in the hot water storage tank 8 in the vertical direction by the tank temperature sensors 42 and 43. The control device 50 may control the start and stop of heat accumulating operation that is the operation of accumulating hot water in the hot water storage tank 8 on the basis of the volume of the hot water or the heat storage amount in the hot water storage tank 8. In the configuration in Fig. 1, two tank temperature sensors 42 and 43 are installed on the hot water storage tank 8, but three or more tank temperature sensors may be installed on the hot water storage tank 8.

[0019] The tank unit 2 further includes a conduit 10, a first pump 11, a second pump 12, a conduit 13a, a conduit 13b, a conduit 16, a three-way valve 17, and a heat exchanger 38. The three-way valve 17 is flow-passage switching means including an a port, a b port, and a c port. The heat exchanger 38 exchanges heat between the heating medium heated in the heat pump device 3 and the water.

[0020] The conduit 10 connects an outlet 8b provided in the lower portion of the hot water storage tank 8 and an inlet for water of the heat exchanger 38 to each other. The second pump 12 is connected to the conduit 10 at a place midway through the conduit 10. The conduit 13a connects an outlet for water of the heat exchanger 38 and the a port of the three-way valve 17 to each other. The conduit 13b connects the c port of the three-way valve 17 and an inlet 8d formed in the upper portion of the hot water storage tank 8 to each other. The conduit 16 connects the b port of the three-way valve 17 and an inlet 8c formed in the lower portion of the hot water storage tank 8 to each other. In Fig. 1, the inlet 8c is located at a position lower than the outlet 8b. The present invention is not limited to such configuration, and the inlet 8c may be located at a position at the same height as the outlet 8b, or the inlet 8c may be located at a position higher than the outlet 8b.

[0021] The conduit 14 connects an outlet for the heating medium of the heat exchanger 38 of the tank unit 2 and an inlet for the heating medium of the heat exchanger 33 of the heat pump device 3 to each other. The first pump 11 is connected to the conduit 14 at a place midway through the conduit 14. The conduit 15 connects an outlet for the heating medium of the heat exchanger 33 of the heat pump device 3 and an inlet for the heating medium of the heat exchanger 38 of the tank unit 2 to each other.

[0022] The following is performed in the heat accumulating operation. The three-way valve 17 is put in a state in which the a port is in communication with the c port, and the b port is shut off. The heat pump device 3, the first pump 11, and the second pump 12 are operated. The heating medium heated in the heat exchanger 33 of the heat pump device 3 flows into the heat exchanger 38 through the conduit 15. The water taken from the outlet 8b of the hot water storage tank 8 flows into the heat exchanger 38 through the conduit 10. In the heat exchanger 38, the heating medium heats the water. That is, the heating medium is cooled by the water. The heating medium cooled in the heat exchanger 38 returns to the heat exchanger 33 through the conduit 14. The hot water heated in the heat exchanger 38 flows into the hot water storage tank 8 from the inlet 8d through the conduit 13a, the three-way valve 17, and the conduit 13b. Hot water is accumulated in the hot water storage tank 8 from the top to the bottom by circulating the heating medium and the water as above.

[0023] In this embodiment, a first circuit connecting the heat exchanger 38 and the heat pump device 3 to each other is formed by the conduit 14 and the conduit 15. A second circuit connecting the heat exchanger 38 and the hot water storage tank 8 to each other is formed by the conduit 10, the conduit 13a, the three-way valve 17, and the conduit 13b.

[0024] The control device 50 can change the flow rate of the heating medium flowing in the first circuit by controlling the capacity of the first pump 11. The rotational speed of the first pump 11 may be variable. The first pump 11 may include a pulse width modulation control type DC motor that can change the rotational speed by a speed command voltage from the control device 50.

[0025] The control device 50 can change the flow rate of the water flowing in the second circuit by controlling the capacity of the second pump 12. The rotational speed of the second pump 12 may be variable. The second pump 12 may include a pulse width modulation control type DC motor that can change the rotational speed by a speed command voltage from the control device 50.

[0026] A first temperature sensor 4 is installed in the conduit 15. The first temperature sensor 4 detects the temperature of the heating medium that has been heated by the heat pump device 3, that is, the temperature of the heating medium flowing out of the heat exchanger 33. The temperature of the heat medium flowing into the heat exchanger 38 can be detected by the first temperature sensor 4. A second temperature sensor 5 is installed in the conduit 14. The second temperature sensor 5 detects the temperature of the heating medium before being heated by the heat pump device 3, that is, the temperature of the heating medium flowing into the heat exchanger 33. The temperature of the heating medium flowing out of the heat exchanger 38 can be detected by the second temperature sensor 5. In the configuration in Fig. 1, the first temperature sensor 4 and the second temperature sensor 5 are in the heat pump device 3, but the first temperature sensor 4 and the second temperature sensor 5 may be arranged in the tank unit 2.

[0027] A third temperature sensor 6 is installed in the conduit 13a. The third temperature sensor 6 detects the temperature of the hot water flowing out of the heat exchanger 38, that is, the temperature of the hot water that has been heated in the heat exchanger 38. A fourth temperature sensor 7 is installed in the conduit 10. The fourth temperature sensor 7 detects the temperature of the water flowing into the heat exchanger 38, that is, the temperature of the water before being heated in the heat exchanger 38.

[0028] The user can set a first hot water supply temperature TH and a second hot water supply temperature TL for the storage type hot water supplying system 1. The second hot water supply temperature TL is a temperature lower than the first hot water supply temperature TH. The remote controller 60 may be capable of receiving the user operation for setting the first hot water supply temperature TH and the second hot water supply temperature TL. The remote controller 60 may transmit information of set values of the first hot water supply temperature TH and the second hot water supply temperature TL that are input into the remote controller 60 by the user to the control device 50. For example, the first hot water supply temperature TH may be set as 60°C and the second hot water supply temperature TL may be set as 50°C.

[0029] The control device 50 may set a target temperature Tp1 of the heating medium that has been heated by the heat pump device 3, that is, the heating medium flowing into the heat exchanger 38 in the heat accumulating operation on the basis of the first hot water supply temperature TH. The target temperature Tp1 is set to be a temperature higher than the first hot water supply temperature TH. The control device 50 may set a value obtained by adding an assumed value α of a terminal temperature difference of the heat exchanger 38 in the heat accumulating operation to the first hot water supply temperature TH as the target temperature Tp1. The terminal temperature difference is a difference between the temperature of the heating medium flowing into the heat exchanger 38 and the temperature of the hot water flowing out of the heat exchanger 38. For example, when it is assumed that the assumed value α of the terminal temperature difference of the heat exchanger 38 is 10°C and the first hot water supply temperature TH is 60°C, the target temperature Tp1 may set as 70°C. In this way, the following is obtained. In the heat accumulating operation, the temperature of the hot water flowing out of the heat exchanger 38 becomes equal to the first hot water supply temperature TH. The hot water of which temperature is equal to the first hot water supply temperature TH is accumulated in the hot water storage tank 8. The hot water of which temperature is equal to the first hot water supply temperature TH set by the user can be supplied from the hot water storage tank 8 to the outside through the hot water supply pipe 21.

[0030] The temperature in the hot water storage tank 8 decreases by supplying hot water to the hot water supply pipe 21 from the hot water storage tank 8 and dissipating heat from the hot water storage tank 8 to the surroundings. When the hot water storage temperature detected by the tank temperature sensor 42 or the tank temperature sensor 43 becomes equal to or below the second hot water supply temperature TL, the control device 50 may start the heat accumulating operation with the detection as a trigger.

[0031] In the heat accumulating operation, the control device 50 adjusts the capacity of the first pump 11 so that a temperature Tout1 of the heating medium that has been heated by the heat pump device 3, that is, the temperature Tout1 detected by the first temperature sensor 4 becomes equal to the target temperature Tp1. When the capacity of the first pump 11 is reduced, the flow rate of the heating medium flowing in the first circuit decreases, and the temperature Tout1 increases. When the capacity of the first pump 11 is increased, the flow rate of the heating medium flowing in the first circuit increases, and the temperature Tout1 decreases. The control device 50 may adjust the capacity of the first pump 11 on the basis of the deviation between the target temperature Tp1 and the temperature Tout1. With use of the deviation, the control device 50 may adjust the capacity of the first pump 11 on the basis of proportional control, integral control, differential control, or the combination of two or three of the above.

[0032] In the heat accumulating operation, the difference between the temperature Tout1 of the heating medium that has been heated by the heat pump device 3 and a temperature Tin1 of the heating medium before being heated by the heat pump device 3 is herein referred to as a heating medium temperature difference ΔT1. That is, the difference is defined as the following expression.

$$\Delta T1 = Tout1 - Tin1 \quad \cdots(1)$$

[0033] In the heat accumulating operation, the difference between a temperature Tout2 of the hot water that has been heated in the heat exchanger 38 and a temperature Tin2 of the water before being heated in the heat exchanger 38 is herein referred to as a water temperature difference ΔT2. That is, the difference is defined as the following expression.

$$\Delta T2 = Tout2 - Tin2 \quad \cdots(2)$$

[0034] The control device 50 can obtain the value of the heating medium temperature difference ΔT1 on the basis of the temperatures detected by the first temperature sensor 4 and the second temperature sensor 5. The control device 50 can obtain the value of the water temperature difference ΔT2 on the basis of the temperatures detected by the third temperature sensor 6 and the fourth temperature sensor 7.

[0035] When the capacity of the second pump 12 is reduced, the following result is obtained. The flow rate of the water flowing in the second circuit decreases, the temperature Tout2 increases, and the water temperature difference ΔT2 increases. The heat exchange amount in the heat exchanger 38 decreases, and hence the temperature Tin1 of the heating medium flowing out of the heat exchanger 38 increases, and the heating medium temperature difference ΔT1 decreases.

[0036] When the capacity of the second pump 12 is increased, the following result is obtained. The flow rate of the water flowing in the second circuit increases, the temperature Tout2 decreases, and the water temperature difference ΔT2 decreases. The heat exchange amount in the heat exchanger 38 increases, and hence the temperature Tin1 of the heating medium flowing out of the heat exchanger 38 decreases, and the heating medium temperature difference ΔT1 increases.

[0037] In the heat accumulating operation, the control device 50 adjusts the capacity of the second pump 12 so that the water temperature difference ΔT2 becomes equal to the heating medium temperature difference ΔT1. That is, the second pump 12 is controlled so that the following expression is satisfied.

$$\Delta T2 = Tout2 - Tin2 = \Delta T1 = Tout1 - Tin1 \quad \cdots(3)$$

[0038] When the water temperature difference ΔT2 tends to be smaller than the heating medium temperature difference ΔT1, the water temperature difference ΔT2 can be approximated to the heating medium temperature difference ΔT1 by being increased by reducing the capacity of the second pump 12. Meanwhile, when the water temperature difference ΔT2 tends to be larger than the heating medium temperature difference ΔT1, the water temperature difference ΔT2 can be approximated to the heating medium temperature difference ΔT1 by being reduced by increasing the capacity of the second pump 12. The control device 50 may adjust the capacity of the second pump 12 on the basis of the deviation between the heating medium temperature difference ΔT1 and the water temperature difference ΔT2. With use of the deviation, the control device 50 may adjust the capacity of the second pump 12 on the basis of proportional control, integral control, differential control, or the combination of two or three of the above.

[0039] The heat exchange capacity of the heat exchanger 38 decreases over time. This is due to the deposition of scale, for example. Scale is thought to be mineral components contained in water such as calcium ion and magnesium ion that have deposited and adhered as carbonate crystals.

[0040] As the heat exchange capacity of the heat exchanger 38 decreases over time, the terminal temperature difference of the heat exchanger 38 increases over time. In the description below, the initial terminal temperature difference of the heat exchanger 38 is referred to as a, and the increase over time is referred to as β. The increase β of the terminal temperature difference of the heat exchanger 38 over time may increase at a rate of about 1°C/year depending on the quality of the water.

[0041] As described above, in the heat accumulating operation, the first pump 11 is controlled so that the temperature Tout1 of the heating medium flowing into the heat exchanger 38 becomes equal to the target temperature Tp1. As a result, the following expression is satisfied.

$$\text{Temperature Tout1} = \text{Target temperature Tp1} \quad \cdots(4)$$

[0042] The hot water storage temperature of the hot water storage tank 8 immediately after the heat accumulating operation can be assumed to be equal to the temperature Tout2 of the hot water that has been heated in the heat exchanger 38. Thus, in the description below, the hot water storage temperature of the hot water storage tank 8 immediately after the heat accumulating operation is referred to as the hot water storage temperature Tout2.

[0043] The temperature Tout2 of the hot water that has been heated in the heat exchanger 38, that is, the hot water storage temperature Tout2 is a value obtained by subtracting the terminal temperature difference of the heat exchanger 38 from the temperature Tout1 of the heating medium flowing into the heat exchanger 38, that is, the target temperature Tp1. The initial terminal temperature difference of the heat exchanger 38 is a. In this case, the hot water storage temperature Tout2 can be calculated by the following expression.

$$\text{Hot water storage temperature Tout2} = \text{Target temperature Tp1} - \alpha \quad \cdots(5)$$

[0044] The terminal temperature difference of the heat exchanger 38 when the heat exchange capacity of the heat exchanger 38 has decreased over time is ($\alpha + \beta$). In this case, the hot water storage temperature Tout2 can be calculated by the following expression.

$$\text{Hot water storage temperature Tout2} = \text{Target temperature Tp1} - (\alpha + \beta) \quad \cdots(6)$$

[0045] As above, in this embodiment, as the heat exchange capacity of the heat exchanger 38 decreases over time, the hot water storage temperature Tout2 decreases by the increase β of the terminal temperature difference of the heat exchanger 38 over time from the initial temperature.

[0046] When the temperature Tout2 decreases by β, the water temperature difference $\Delta T2$ decreases by β in accordance with the expression (2) described above. When the water temperature difference $\Delta T2$ decreases, the heat exchange amount in the heat exchanger 38 decreases, and hence the temperature Tin1 of the heating medium flowing out of the heat exchanger 38 increases. Even when the temperature Tin1 increases, the temperature Tout1 is maintained at a value equal to the target temperature Tp1 in accordance with the expression (4) described above. As a result, the heating medium temperature difference $\Delta T1$ decreases in accordance with the expression (1) described above. In accordance with the expression (3) described above, $\Delta T2 = \Delta T1$ is satisfied. Thus, the heating medium temperature difference $\Delta T1$ also decreases by β. As a result, in this embodiment, the temperature Tin1 of the heating medium before being heated by the heat pump device 3 increases by β from the state before the heat exchange capacity of the heat exchanger 38 decreases over time.

(Comparative example)

[0047] In a control method of a comparative example, the following is performed. A target hot water storage temperature Tp is set to a constant value. For example, Tp=TH may be satisfied. In the heat accumulating operation, the capacity of the second pump 12 is adjusted so that the temperature Tout2 of the hot water flowing out of the heat exchanger 38 becomes equal to the target hot water storage temperature Tp. When the terminal temperature difference of the heat exchanger 38 increases from α to ($\alpha + \beta$) over time, the flow rate of the water flowing in the second circuit needs to be reduced in order to maintain the temperature Tout2 of the hot water flowing out of the heat exchanger 38 at the target hot water storage temperature Tp. Thus, the capacity of the second pump 12 is reduced. In order to maintain the temperature Tout2 at the target hot water storage temperature Tp in the comparative example, the flow rate of the water flowing in the second circuit needs to be lower than that in this embodiment. Therefore, in the comparative example, the heat exchange amount in the heat exchanger 38 becomes even more lower than this embodiment, and the temperature Tin1 of the heating medium flowing out of the heat exchanger 38, that is, the temperature Tin1 of the heating medium before being heated by the heat pump device 3 rises even more than that in this embodiment. In the comparative example, the increase in the temperature Tin1 from the state before the heat exchange capacity of the heat exchanger 38 has decreased over time is larger than β.

[0048] The energy efficiency, for example, the coefficient of performance of the heat pump device 3 becomes lower as the temperature Tin1 of the heating medium before being heated by the heat pump device 3 becomes higher. In this embodiment, the increase in the temperature Tin1 as the heat exchange performance of the heat exchanger 38 decreases over time can be smaller than that in the comparative example. As a result, in this embodiment, the decrease in the energy efficiency, for example, the decrease in the coefficient of performance of the heat pump device 3 when the heat exchange performance of the heat exchanger 38 decreases over time can be smaller than that of the comparative example.

[0049] In this embodiment, the temperature Tout2 of the hot water flowing out of the heat exchanger 38 in the heat accumulating operation decreases in accordance with the decrease in the heat exchange performance of the heat exchanger 38 over time. In this embodiment, it is desired that the second pump 12 be controlled so that the water temperature difference $\Delta T2$ becomes equal to the heating medium temperature difference $\Delta T1$ even when the temperature Tout2 of the hot water flowing out of the heat exchanger 38 in the heat accumulating operation does not reach the set value of the first hot water supply temperature TH. In this manner, the decrease in the energy efficiency of the heat pump device 3 can be reduced more reliably even when the heat exchange performance of the heat exchanger 38 decreases over time.

[0050] When the temperature of the heating medium heated in the heat pump device 3 becomes higher, the energy efficiency of the heat pump device 3 becomes lower. In this embodiment, it is desired that the target temperature Tp1 of the heating medium heated by the heat pump device 3 not be changed even when the temperature Tout2 of the hot water flowing out of the heat exchanger 38 in the heat accumulating operation does not reach the set value of the first hot water supply temperature TH. In this manner, the decrease in the energy efficiency of the heat pump device 3 can be reduced more reliably even when the heat exchange performance of the heat exchanger 38 decreases over time.

[0051] In this embodiment, it is desired that the target temperature Tp1 of the heating medium heated by the heat pump device 3 be increased when the temperature Tout2 of the hot water flowing out of the heat exchanger 38 in the heat accumulating operation does not reach the set value of the second hot water supply temperature TL. In this manner, the temperature of the hot water stored in the hot water storage tank 8 is prevented from becoming lower than the set value of the second hot water supply temperature TL. As a result, the hot water of which temperature is the second hot water supply temperature TL set by the user can be reliably supplied from the hot water storage tank 8.

[0052] The control device 50 may limit the upper limit of the target temperature Tp1 of the heating medium heated by the heat pump device 3 in the heat accumulating operation. For example, the control device 50 may set the upper limit so that the target temperature Tp1 does not exceed 90°C. When the target temperature Tp1 is set too high, the life of the heat pump device 3 can be affected. Bad influence on the life the heat pump device 3 can be reliably prevented by limiting the upper limit of the target temperature Tp1.

[0053] The control device 50 may limit the lower limit of the flow rate of the water flowing in the second circuit in the heat accumulating operation. For example, the control device 50 may set a lower limit for the capacity of the second pump 12 so that the flow rate of the water flowing in the second circuit does not fall below 1 L/min. When the flow rate of the water flowing in the second circuit in the heat accumulating operation is too low, the heating power can become insufficient. The heating power can be reliably prevented from becoming insufficient by limiting the lower limit of the flow rate of the water flowing in the second circuit.

[0054] When the heat exchange performance of the heat exchanger 38 excessively decreases over time, the temperature Tout2 of the hot water flowing out of the heat exchanger 38 sometimes does not reach a reference value even when the target temperature Tp1 is increased to the upper limit and the flow rate of the water flowing in the second circuit is reduced to the lower limit in the heat accumulating operation. In such a case, the control device 50 may notify the user of an abnormality. At this time, the abnormality may be displayed on the display of the remote controller 60, or an audio guide indicating the abnormality may be output from the remote controller 60. The user can be prompted to repair or exchange the heat exchanger 38 by notifying the user of the abnormality. The reference value described above may be equal to the set value of the second hot water supply temperature TL.

[0055] When the heat accumulating operation is started, the control device 50 may activate the second pump 12 after the heat pump device 3 and the first pump 11 are activated. The value of the heating medium temperature difference $\Delta T1$ can be unstable immediately after the activation of the heat pump device 3 and the first pump 11. When the second pump 12 is controlled so that the water temperature difference $\Delta T2$ becomes equal to the heating medium temperature difference $\Delta T1$ while the value of the heating medium temperature difference $\Delta T1$ is unstable, hunting is likely to occur. The control stability of the second pump 12 can be enhanced by starting the operation of the second pump 12 after a certain amount of time has passed after the heat pump device 3 and the first pump 11 have been activated and after the value of the heating medium temperature difference $\Delta T1$ has been stabilized. Although it depends on the lengths of the conduits 14 and 15, it can take one or more minutes for the heating medium to circulate in the first circuit for one or more cycles and for the heating medium temperature difference $\Delta T1$ to be stabilized. Thus, the operation of the second pump 12 may be started after one minute has passed after the operation of the first pump 11 has started.

Second embodiment

[0056] Next, a second embodiment is described with reference to Fig. 2. Differences from the abovementioned embodiment 1 are mainly described, and description of the same parts or corresponding parts is simplified or omitted.

[0057] A storage type hot water supplying system 1 of the second embodiment illustrated in Fig. 2 includes a first flow rate sensor 18 and a second flow rate sensor 19. The first flow rate sensor 18 is installed in the conduit 15. The first flow rate sensor 18 detects the volumetric flow rate of the heating medium flowing in the first circuit. The first flow rate sensor 18 may be installed in the conduit 14 instead of the conduit 15. The second flow rate sensor 19 is installed in the conduit 10. The second flow rate sensor 19 detects the volumetric flow rate of the water flowing in the second circuit. The second flow rate sensor 19 may be installed in the conduit 13a or the conduit 13b instead of the conduit 10.

[0058] In the heat accumulating operation, the control device 50 may adjust the capacity of the second pump 12 so that the volumetric flow rate of the water detected by the second flow rate sensor 19 becomes equal to the volumetric flow rate of the heating medium detected by the first flow rate sensor 18. In a case where water is used as the heating medium of the first circuit, when the volumetric flow rate of the water flowing in the second circuit becomes equal to the volumetric flow rate of the water that is the heating medium flowing in the first circuit, the water temperature difference $\Delta T2$ accordingly becomes equal to the heating medium temperature difference $\Delta T1$. As a result, an effect similar to that in the first embodiment can be obtained by the configuration as described above.

[0059] In the heat accumulating operation, the control device 50 may adjust the capacity of the second pump 12 so that the heat capacity flow rate of the water flowing in the second circuit becomes equal to the heat capacity flow rate of the heating medium flowing in the first circuit. The control device 50 may calculate a heat capacity flow rate $Cph \times \rho h \times Vh$ [kW/K] of the heating medium by multiplying prestored values of a specific heat Cph [kJ/kgK] of the heating medium and a density ρh [kg/m^3] of the heating medium by a volumetric flow rate Vh [m^3/second] of the heating medium detected by the first flow rate sensor 18. The control device 50 may calculate a heat capacity flow rate $Cpw \times \rho w \times Vw$ [kW/K] of the water by multiplying prestored values of a specific heat Cpw [kJ/kgK] of the water and a density ρw [kg/m^3] of the water by a volumetric flow rate Vw [m^3/second] of the water detected by the second flow rate sensor 19. When the heat capacity flow rate of the water flowing in the second circuit becomes equal to the heat capacity flow rate of the heating medium flowing in the first circuit, the water temperature difference $\Delta T2$ accordingly becomes equal to the heating medium temperature difference $\Delta T1$. As a result, an effect similar to that in the first embodiment can be obtained by the configuration as described above. The method described above can be applied to a case in which the heating medium of the first circuit is not water.

[0060] According to the second embodiment, an effect similar to that in the first embodiment can be obtained even without using the information detected by the second temperature sensor 5, the third temperature sensor 6, and the fourth temperature sensor 7. The storage type hot water supplying system 1 of the second embodiment does not necessarily need to include the second temperature sensor 5, the third temperature sensor 6, and the fourth temperature sensor 7.

[0061] The functions of the control device 50 included in the storage type hot water supplying system 1 of the first embodiment and the second embodiment may be implemented by a processing circuit. In the examples illustrated in Fig. 1 and Fig. 2, the processing circuit of the control device 50 includes at least one processor 51 and at least one memory 52. When the processing circuit includes at least one processor 51 and at least one memory 52, the functions of the control device 50 may be implemented by software, firmware, or a combination of software and firmware. At least one of the software and the firmware may be described as a program. At least one of the software and the firmware may be stored in at least one memory 52. At least one processor 51 may implement the functions of the control device 50 by reading and executing a program stored in at least one memory 52. At least one memory 52 may include a nonvolatile semiconductor memory or a volatile semiconductor memory, or a magnetic disk.

[0062] The processing circuit of the control device 50 may include at least one dedicated hardware. When the processing circuit includes at least one dedicated hardware, the processing circuit may be, for example, a single circuit, a composite circuit, a programmed processor, a parallel-programmed processor, an ASIC (Application Specific Integrated Circuit), an FPGA (Field-Programmable Gate Array), or a combination of the above. Each of the functions of the units of the control device 50 may be implemented by the processing circuit. The functions of the units of the control device 50 may be collectively implemented by the processing circuit. A part of the functions of the control device 50 may be implemented by dedicated hardware, and other parts of the functions of the control device 50 may be implemented by software or firmware. The processing circuit may implement the functions of the control device 50 by hardware, software, firmware, or a combination of the above.

[0063] The present invention is not limited to a configuration in which the operation of the storage type hot water supplying system 1 is controlled by a single control device. The present invention may employ a configuration in which the operation of the storage type hot water supplying system 1 is controlled by a plurality of control devices in cooperation with each other.

[Reference Signs List]

[0064]

1	storage type hot water supplying system
2	tank unit
3	heat pump device
4	first temperature sensor
5	second temperature sensor
6	third temperature sensor
7	fourth temperature sensor
8	hot water storage tank
8a	inlet
8b	outlet
8c,	8d inlet
8e	outlet
9	water supply pipe

10	conduit
11	first pump
12	second pump
13a, 13b, 14, 15, 16	conduit
17	three-way valve
18	first flow rate sensor
19	second flow rate sensor
21	hot water supply pipe
31	compressor
33	heat exchanger
34	decompression device
35	refrigerant pipe
36	evaporator
37	decompression valve
38	heat exchanger
42, 43	tank temperature sensor
50	control device
51	processor
52	memory
60	remote controller

Claims

1. A storage type hot water supplying system, comprising:

heating means for heating a heating medium;
a heat exchanger configured to exchange heat between the heating medium and water;
a hot water storage tank configured to store hot water heated in the heat exchanger;
a first pump configured to circulate the heating medium in a first circuit connecting the heat exchanger and the heating means to each other;
a second pump configured to circulate water in a second circuit connecting the heat exchanger and the hot water storage tank to each other; and
control means for controlling the first pump and the second pump,
wherein, in a heat accumulating operation for accumulating hot water in the hot water storage tank, the first pump is controlled so that a temperature of the heating medium heated by the heating means becomes equal to a target temperature, and the second pump is controlled so that a water temperature difference that is a difference between a temperature of the hot water heated in the heat exchanger and a temperature of the water before being heated in the heat exchanger becomes equal to a heating medium temperature difference that is a difference between the temperature of the heating medium heated by the heating means and a temperature of the heating medium before being heated by the heating means.

2. The storage type hot water supplying system according to claim 1, further comprising means for receiving a user operation for setting a first hot water supply temperature and a second hot water supply temperature lower than the first hot water supply temperature, wherein:

the target temperature is a temperature higher than a set value of the first hot water supply temperature; and
the second pump is controlled in the heat accumulating operation so that the water temperature difference becomes equal to the heating medium temperature difference even when the temperature of the hot water heated in the heat exchanger does not reach the set value of the first hot water supply temperature.

3. The storage type hot water supplying system according to claim 2, wherein the target temperature is not changed even when the temperature of the hot water heated in the heat exchanger does not reach the set value of the first hot water supply temperature in the heat accumulating operation.

4. The storage type hot water supplying system according to claim 2 or 3, wherein the target temperature is increased when the temperature of the hot water heated in the heat exchanger does not reach a set value of the second hot water supply temperature in the heat accumulating operation.

5. The storage type hot water supplying system according to any one of claims 1 to 4, further comprising:

means for detecting a flow rate of the heating medium flowing in the first circuit; and
means for detecting a flow rate of the water flowing in the second circuit,
wherein the second pump is controlled in the heat accumulating operation so that a volumetric flow rate or a heat capacity flow rate of the water flowing in the second circuit becomes equal to a volumetric flow rate or a heat capacity flow rate of the heating medium flowing in the first circuit.

6. The storage type hot water supplying system according to any one of claims 1 to 5, wherein the control means is configured to limit an upper limit of the target temperature in the heat accumulating operation.

7. The storage type hot water supplying system according to any one of claims 1 to 6, wherein, when the heat accumulating operation is started, the second pump is activated after the first pump is activated.

8. The storage type hot water supplying system according to any one of claims 1 to 7, wherein the control means is configured to limit a lower limit of a flow rate of the water flowing in the second circuit in the heat accumulating operation.

9. The storage type hot water supplying system according to any one of claims 1 to 8, further comprising means for notifying a user of an abnormality when the temperature of the hot water heated in the heat exchanger does not reach a reference value in the heat accumulating operation.

FIG. 1

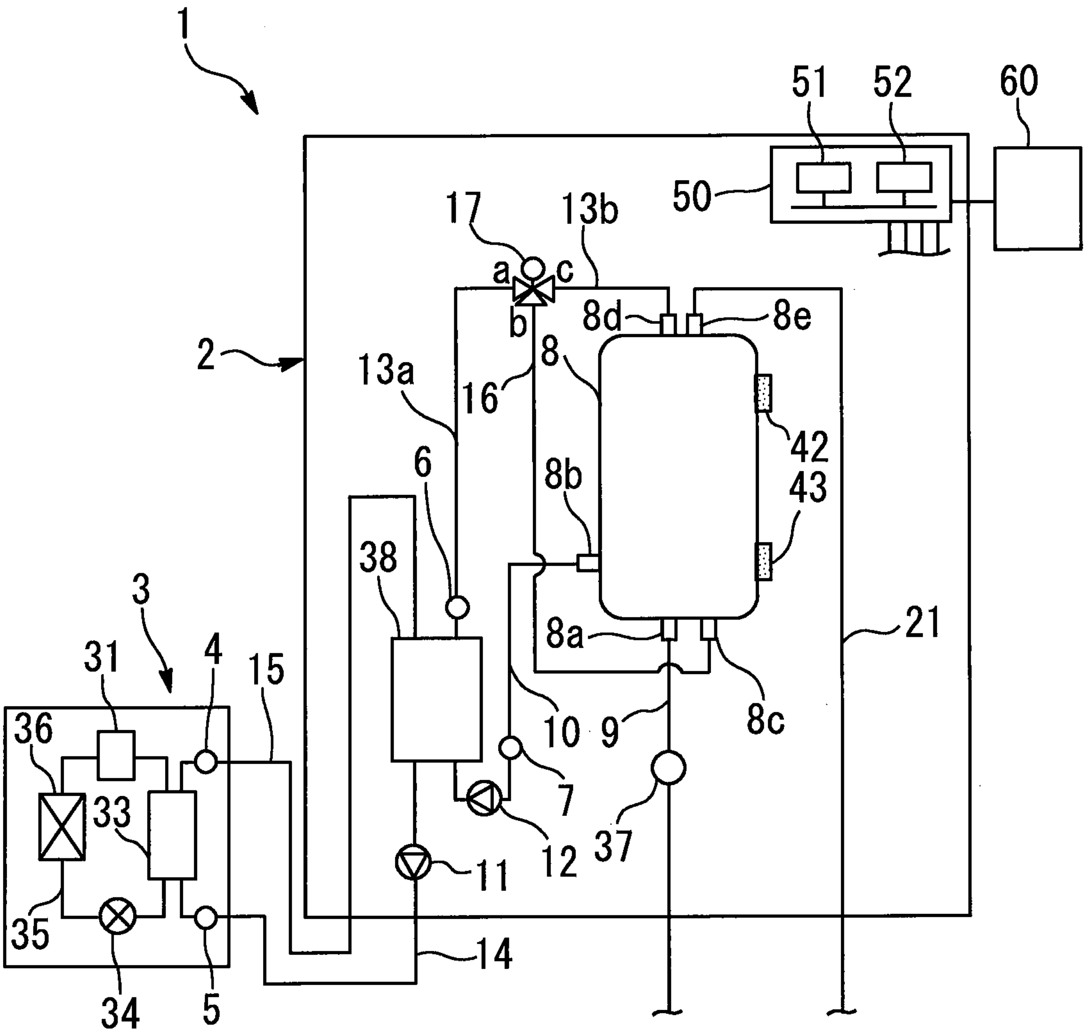
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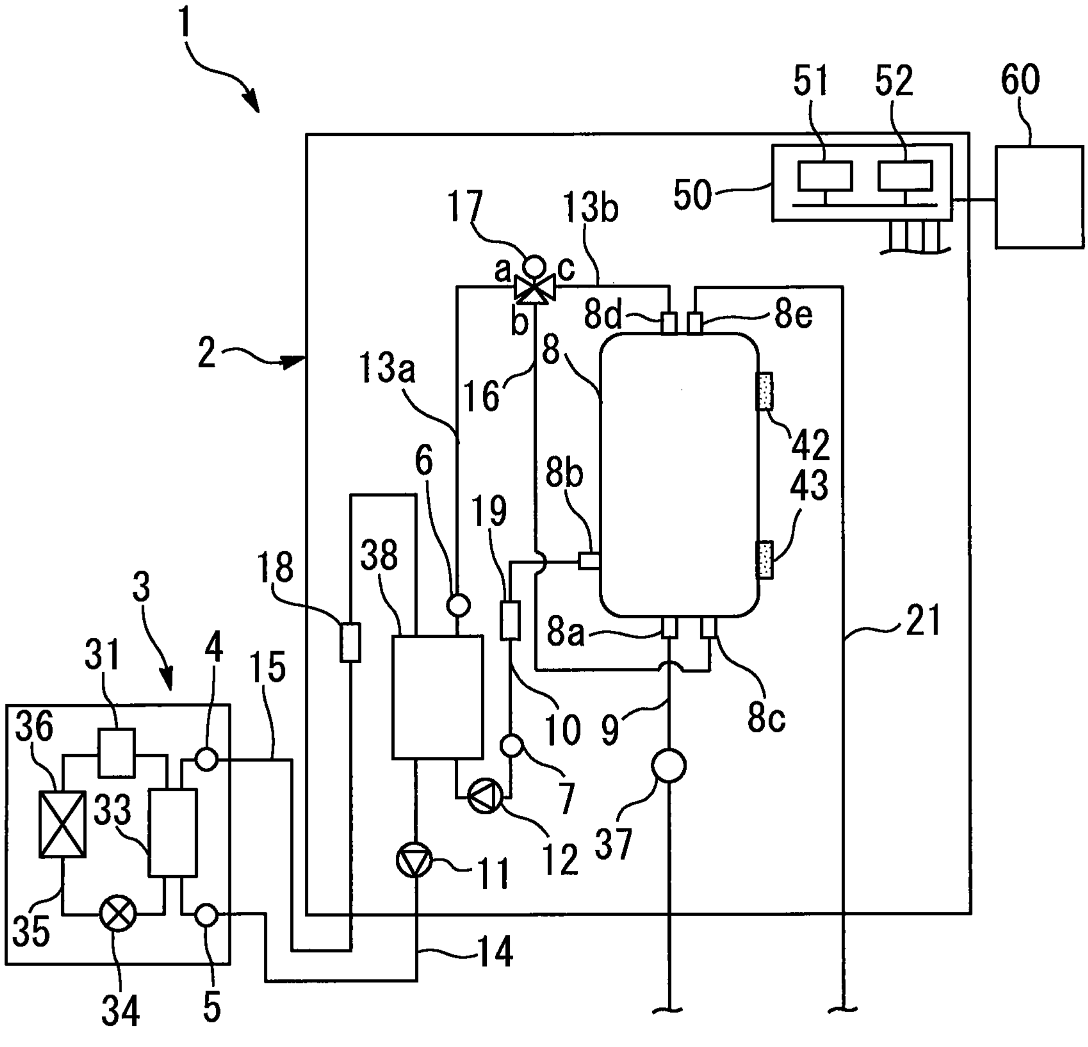
FIG. 2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19
38
18
3
31
4
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8a
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8c
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/055083

A. CLASSIFICATION OF SUBJECT MATTER
F24H1/18(2006.01)i, *F24H4/02*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24H1/18, F24H4/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-036648 A (Mitsubishi Electric Corp.), 21 February 2013 (21.02.2013), paragraphs [0013] to [0082]; fig. 1 to 14 (Family: none)	1-9
A	JP 2014-066395 A (Mitsubishi Electric Corp.), 17 April 2014 (17.04.2014), paragraphs [0006] to [0057]; fig. 1 to 8 (Family: none)	1-9
A	JP 61-029649 A (Matsushita Electric Industrial Co., Ltd.), 10 February 1986 (10.02.1986), pages 1 to 3 (Family: none)	1-9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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