

SOLAR ENERGY APPLICATION SYSTEM

TECHNICAL FIELD

[0001]

5 The invention relates to a solar energy application system.

BACKGROUND ART

[0002]

10 Application of natural energy independent of fossil fuel is getting more attention. For example, when water is heated, a technology has been known in which solar light is used. As an example of such a technology, Patent Literature 1 discloses a technology in which the solar light is used with a water-
15 based heat collector and liquid heating medium pipes connected to solar cells. Also, in Patent Literature 2, a technology is disclosed, in which solar cells are mounted on a front surface of a direct expansion type heat exchanger of a heat pump and solar light is used as energy for heating air and water.

20

PRIOR ART DOCUMENTS

PATENT LITERATURES

[0003]

 Patent Literature 1: JP H05-66065 A
25 Patent Literature 2: JP H07-253249 A

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004]

30 However, the technologies disclosed in the above Patent Literatures have following problems. Driving power is needed to drive each element constituting a system. The driving power may be large depending on an operating condition. Therefore, electric power consumption amount may increase depending on the
35 operating condition, and electric power more than electric

power amount generated by the solar cells may be consumed. Consequently, application efficiency of solar energy may decrease. Also, even if electric power more than the generated electric power is not consumed, energy efficiency is not still
5 enough in the disclosed systems.

[0005]

The present invention is oriented for solving the above problems and aims to provide a solar energy application system which is capable of improving application efficiency of solar
10 energy over the prior art.

MEANS TO SOLVE THE PROBLEMS

[0006]

As a result of diligent endeavor to solve the problems,
15 the inventors found to solve the problems by providing at least a heat exchanger and a heat pump or another heat exchanger and a circulation pump to control circulated amount of a heating medium and accomplished the invention.

20 EFFECT OF THE INVENTION

[0007]

The invention can provide a solar energy application system which improves application efficiency of solar energy over the prior art.

25

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a diagram illustrating a structure of a solar energy application system according to a first embodiment;

30 FIG. 2 is a graph illustrating recovered heat amount to a heating medium temperature supplied to a heat exchanger 2 and electric power amount generated by a solar cell 1;

FIG. 3 is a flowchart illustrating control in a solar energy application system 100;

35 FIG. 4 is a diagram illustrating a structure of the solar

energy application system according to a second embodiment; and

FIG. 5 is a diagram illustrating a structure of the solar energy application system according to a third embodiment.

5 EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0009]

[1. First embodiment]

<Structure>

As illustrated in FIG. 1, a solar energy application
10 system 100 has a solar cell 1, a heat exchanger 2 which is
provided in close contact (adjacent) on a back surface (a
reverse surface of a solar light irradiation surface) of the
solar cell 1, a heat pump 3, and an inverter (INV)-controlled
pump 4. The heat exchanger 2 and the heat pump 3 are connected
15 via a pipe and a heating medium circulates between the heat
exchanger 2 and the heat pump 3 via the pipe. Arrows in FIG. 1
indicate flow directions of a cooling medium, the heating
medium and water (a heated medium).

[0010]

20 Further, the solar energy application system 100 has a
calculation control unit 5 which controls the circulation of
the heating medium. Though the detail thereof will be
explained later, the calculation control unit 5 particularly
calculates electricity consumption in the energy application
25 system 100 and generated electric power amount of the solar
cell 1. The calculation control unit 5 controls circulated
flow amount of the heating medium by controlling the pump 4
based on the calculation result.

[0011]

30 Besides, the solar energy application system 100 has a
current sensor 61 which measures electric current and a voltage
sensor 62 which measures electric voltage in the solar cell 1,
a temperature sensor 71 which measures a temperature of heating
medium discharged from the heat pump 3, a temperature sensor 72
35 which measures a temperature of heating medium discharged from

the heat exchanger 2, a temperature sensor 79 which measures an external temperature (outdoor temperature), and a flow sensor 91 which measures flow amount of the heating medium discharged from the heat exchanger 2.

5 [0012]

Also, the solar energy application system 100 has a system which supplies water to be heated in the heat pump 3 and stores the heated water. Specifically, the solar energy application system 100 has an inverter-controlled pump 33, a
10 flow sensor 93 which measures water flow supplied to the heat pump 3, a temperature sensor 73 which measures a temperature of water supplied to the heat pump 3, a temperature sensor 74 which measures a temperature of water (that is, the heated water) discharged from the heat pump 3, and a hot water tank 13
15 which stores water discharged from the heat pump 3.

[0013]

Each element will be explained hereinbelow.

[0014]

The solar cell 1 is configured to convert energy of solar
20 light to electric power and to supply the electric power to an outside. In the embodiment, the obtained electric power is supplied to an external load (not illustrated). In the embodiment, the obtained electric power is also used for driving each element (such as the heat pump 3, the pump 4)
25 constituting the solar energy application system 100.

[0015]

The heat exchanger 2 is configured to cool down the solar cell 1. Specifically, by flowing the heating medium having a low temperature to the heat exchanger 1, the heat exchanger 2
30 transmits heat of the solar cell 1 to the heating medium, thereby a temperature of the solar cell 1 is lowered. The heating medium (the heating medium to which the heat from the solar cell 1 has been transmitted) discharged from the heat exchanger 2 is supplied to the heat pump 3 described later.
35 The heating medium may be water (facilities which prevents

water from freezing under low temperature are preferably provided separately), an antifreezing solution, or the like. Further, gas such as carbon dioxide may be used.

[0016]

5 The heat pump 3 is configured to be supplied with the heating medium discharged from the heat exchanger 2. The heat pump 3 has, as illustrated in FIG. 1, an evaporator 3a, a compressor 3b, a condenser 3c and an expansion valve 3d. The heating medium is supplied to the evaporator 3a. A cooling
10 medium flows in the heat pump 3 in a direction illustrated in FIG. 1. While, water is supplied to the condenser 3c in the heat pump 3.

[0017]

 After the cooling medium obtains heat from the heating
15 medium in the evaporator 3a, the cooling medium is compressed in the compressor 3b. Thus, the cooling medium is under elevated temperature and pressure. Then, the cooling medium under elevated temperature and pressure is cooled down in the condenser 3c. In other words, the heat of the cooling medium
20 under elevated temperature and pressure is transmitted to the water supplied to the heat pump 3 (the condenser 3c). Thus, heated water (hot water) is obtained. The obtained hot water is stored in the hot water tank 13. While, the cooled cooling medium is expanded by the expansion valve 3d to be under low
25 temperature and pressure. Then, the cooling medium is supplied to the evaporator 3a again.

[0018]

 In the embodiment, the heat pump 3 is so controlled such that a temperature measured by the temperature sensor 74 is set
30 at 45 degrees C to store hot water having a temperature appropriate for usage.

[0019]

 The pump 4 is configured to circulate the heating medium between the heat exchanger 2 and the heat pump 3. Further, the
35 pump 4 changes circulated amount of the heating medium. The

pump 4 is inverter-controlled and is driven at a higher rotating speed when flow amount of the heating medium is much. On the other hand, when the flow amount of the heating medium is less, the pump 4 is driven at a lower rotating speed. With such an inverter-controlled pump, the rotating speed can be changed based on the flow amount. Thus, the rotating speed of the pump 4 slows when the flow amount of the heating medium is less, resulting in reduction of electricity consumption.

[0020]

10 The calculation control unit 5 is connected to each sensor (such as the voltage sensor, the voltage sensor, the temperature sensors, the flow sensors), each pump and each element (such as the heat exchanger 2) via electric signal cables (not illustrated). The calculation control unit 5 receives information (electric signals) from each sensor and each pump and the like for calculation (computation) and controls motion of each pump and each element based on the calculation result.

[0021]

20 The calculation control unit 5 is one form as flow control unit which changes the circulated amount of the heating medium by controlling the pump 4. Shortly, the calculation control unit 5 has a communication unit 5a which is connected to each sensor, each pump and each element to receive the electric signals therefrom, an optimum output calculation unit 5b which determines the heating medium amount flowing in the heat exchanger 2, a simulation unit 5c which simulates (calculates) the electric power amount generated in the solar cell 1 and the electricity consumption amount in the solar energy application system 100, and a control unit 5d which controls the rotating speed (that is, an inverter frequency) of each pump. A specific control by the calculation control unit 5 will be described later.

[0022]

35 The calculation control unit 5 has, especially, a CPU

(Central Processing Unit), a ROM (Read Only Memory), a RAM (Random Access Memory), a HDD (hard Disk Drive) and the like.

[0023]

Also, appropriate devices and elements may be used for the temperature sensors 71, 72, 73, 74, 79, the flow sensors 91, 93, the current sensor 61, the voltage sensor 62 and the pumps 4, 33.

[0024]

<Control>

10 Firstly, a property of the solar cell 1 will be explained.

As illustrated in FIG. 2, when a heating medium temperature at an inlet of the heat exchanger 2 rises, generated electric power amount of the solar cell 1 and recovered heat amount to the heating medium decreases. More specifically, when the temperature at the inlet rises, the solar cell 1 is not cooled enough and the temperature of the solar cell 1 rises up. Therefore, efficiency of the solar cell 1 decreases and the electric power generation decreases. Further, when the temperature at the inlet rises, the temperature (front surface temperature) of the solar cell 1 increases. Therefore, since radiation amount from the front surface of the solar cell 1 to the outside rises, the recovered heat amount of the heat exchanger provided on the back surface of the solar cell 1 falls down.

25 [0025]

Referring to FIG. 3, the control by the calculation control unit 5 in the solar energy application system 100 will be explained. The calculation control unit 5 controls the flow amount of the heating medium supplied to the heat exchanger 2 such that the electricity consumption in the solar energy application system 100 becomes as less as possible and the generated electric power amount of the solar cell 1 becomes as much as possible. In other words, the calculation control unit 5 controls supplied flow amount of the heating medium to the heat exchanger 2 such that difference between the generated

electric power amount and the electricity consumption is set at the maximum. A specific example will be explained below.

[0026]

Location information such as latitude and longitude of a location where the solar cell 1 is installed is input in the optimum output calculation unit 5b in the calculation control unit 5 (step S101). As the location information, an electric file previously recording location information by an input device or the like such as a keyboard (not illustrated) is prepared and the values recorded in the electric file are input. Further, simulation start time is input. Then, the optimum output calculation unit 5b obtains measured values from the current sensor 61, the voltage sensor 62, each temperature sensor and each flow sensor.

15 [0027]

The optimum output calculation unit 5b calculates the electric power amount generated by the solar cell 1 based on the measured current value and the measured voltage value of the solar cell 1 (step S102). The generated electric power amount which is calculated is an actual generated electric power amount. The solar cell 1 is connected to a secondary cell (not illustrated). Shortly, the electric power generated by the solar cell 1 is charged in the secondary cell. Thus, electric current flows in the solar cell 1.

25 [0028]

The optimum output calculation unit 5b calculates the front surface temperature of the solar cell 1 based on the generated electric power amount which is calculated (step S103). The front surface temperature is calculated based on a predetermined formula (thermal balance, a heat-transfer property) concerning the electric power generated in the solar cell 1 and the temperature of the heating medium supplied to and discharged from the heat exchanger 2.

[0029]

35 In other words, the optimum output calculation unit 5b

calculates heat amount (i.e. heat exchange amount between the solar cell 1 and the heat exchanger 2) received by the heating medium in the heat exchanger 2 with the temperature sensors 71, 72 and the flow sensor 91. Specifically, the heating medium temperature (that is, the temperature of the heating medium discharged from the heat pump 3 (specifically, the above-mentioned evaporator 3a)) at the inlet of the heat exchanger 2 is measured by the temperature sensor 71. Further, the heating medium temperature (that is, the temperature of the heating medium supplied to the heat pump 3) at an outlet of the heat exchanger 2 is measured by the temperature sensor 72. Then, difference of the heating medium temperatures at the inlet and at the outlet of the heat exchanger 2 is calculated. The heat amount received by the heating medium in the heat exchanger 2 is calculated based on the difference and the flow amount of the heating medium measured by the flow sensor 91.

[0030]

The front surface temperature of the solar cell 1 is calculated in consideration of the obtained heat amount by the calculation, the outdoor temperature measured by the temperature sensor 79, the heat-transfer property of the heat exchanger 2, the thermal balance in the system, and the like. In step S103, the radiation amount from the solar cell 1 to the outside (i.e. outside the system), a radiation amount from the heat exchanger 2 to the outside and the like are also calculated, in addition to the front surface temperature.

[0031]

Then, the optimum output calculation unit 5b calculates an orbit of the sun based on the latitude, the longitude, time and the like, input in step S101, to calculate solar altitude and azimuth. Solar insolation amount on the solar cell 1 is calculated based on the generated electric power amount which is calculated in step S102 and the front surface temperature calculated in step S103 (step S104). The solar insolation amount is calculated based on a predetermined formula

reflecting temperature-efficiency property of the solar cell 1.
[0032]

After obtaining the generated electric power amount, the front surface temperature and the solar insolation amount and the like by the calculations above, the optimum output calculation unit 5b sets supply amount of the heating medium supplied to the heat exchanger 2 (step S105). Shortly, the flow amount value by the pump 4 is set. Initial flow amount in the embodiment is set to the maximum flow amount which can be changed in the pump 4.

[0033]

Next, the simulation unit 5c executes control (step S106 to step S111) below.

[0034]

Firstly, the heating medium temperature is input in the simulation unit 5c. The input at this stage is executed as a same manner as the input manner in the above-mentioned step S101. It is noted that, in the embodiment, the outdoor temperature measured by the temperature sensor 79 is set as the heating medium temperature (the temperature at the outlet of the heat exchanger 2) (step S106).

[0035]

Then, the electricity consumption of the pump 4 is calculated based on the set heating medium temperature and the flow amount of the heating medium set in step S105 (step S107). Further, the electricity consumption of the pump 33 is calculated similarly based on the flow sensor 93 (step S107). These calculations are executed based on a relationship between the flow amount and the electricity consumption in each pump.

[0036]

Then, the electricity consumption of the heat pump 3 is also calculated (step S108). In other words, the simulation unit 5c calculates the electricity consumption of the heat pump 3 and the heating medium temperature at the outlet of the evaporator 3a in the heat pump 3 based on the property of the

heat pump 3 preliminary set.

[0037]

Further, the calculation uses the temperature at the inlet, the temperature at the outlet, the flow amount through the condenser 3c in the heat pump 3, the temperature at the inlet and the flow amount through the evaporator 3a as parameters. The measured values by the temperature sensor 73, 74 and the flow sensor 93 are used as the temperature at the inlet, the temperature at the outlet and the flow amount through the condenser 3c in the heat pump 3, respectively. Further, the flow amount of the heating medium in the evaporator 3a is set to the value which is set in step S105 (the value set in step S113 at or after a second calculation), and the heating medium temperature at the inlet of the evaporator 3a is set to the temperature value at the outlet of the heat exchanger 2 which is set in step S106 (the temperature value at the outlet of the heat exchanger 2 calculated in step S109 at or after a second calculation).

[0038]

Based on the electricity consumption of the pumps 4, 33 calculated in the above step S107 and the electricity consumption of the heat pump 3 calculated in step S108, the simulation unit 5c calculates the electric power amount generated in the solar cell 1 and the thermal balance between the solar cell 1 and the heat exchanger 2 (step S109). At first, the front surface temperature of the solar cell 1 is calculated. A specific calculation manner is as same as the manner explained in step S103. With the calculation for the thermal balance, the temperature at the outlet of the heat exchanger 2, that is, the heating medium temperature at the inlet of the evaporator 3a in the heat pump 3 is calculated. The front surface temperature to be calculated is an estimated value of the flow amount of the heating medium set in step S105 (the flow amount of the heating medium set in step S113 at or after a second calculation). Further, the electric power

amount generated in the solar cell 1 is calculated by applying the front surface temperature to the predetermined formula reflecting the temperature-efficiency property of the solar cell 1.

5 [0039]

Further, the calculation uses the solar insolation amount, the outdoor temperature, the electric power amount generated in the solar cell 1, the heating medium temperature at the inlet and the flow amount of the heating medium as parameters. The value calculated in step S104 is used as the solar insolation amount and the measured value by the temperature sensor 79 is used as the outdoor temperature. Further, the value calculated in step S102 (the calculated value in step S109 previously at or after a second calculation) is used as the electric power generated in the solar cell 1. Still further, the heating medium temperature at the outlet of the evaporator 3a in the heat pump 3 calculated in step S108 is used as the heating medium temperature at the inlet of the heat exchanger 2. The value set in step S105 (the value set in step S113 at or after a second time) is used as the flow amount of the heating medium. The heating medium temperature at the outlet of the heat exchanger 2 calculated (estimated) in step S109 is stored in a memory unit (not illustrated).

[0040]

25 While the calculated heating medium temperature at the outlet of the heat exchanger 2 is stored, the simulation unit 5c compares (decides) the heating medium temperature at the outlet of the heat exchanger 2 which was lastly calculated and already stored with the value currently calculated (step S110).
30 In a first calculation, since there is no compared object, the decision is not made. Specifically, the simulation unit 5c decides whether difference between the last stored value and the current calculated value is smaller than a predetermined threshold (for example, 0.1 degrees C or less) (whether it is
35 converged).

[0041]

If the convergence result is that the difference is not converged (No in step S110), step S107 to step S110 are repetitively executed to execute the convergence decision again.

5 On the other hand, if the convergence result is that the difference is converged (Yes in step S110), step S111 is executed. The difference between the generated electric power amount which is calculated and the electricity consumption calculated in step S107 and step S108 is calculated and is
10 stored in the memory unit (not illustrated) (step S111). The difference is stored with the flow amount set in step S105. When the heating medium temperature (the estimated value) at the outlet of the heat exchanger 2 converges, the temperature (the estimated value) at the inlet of the heat exchanger 2 also
15 converges.

[0042]

The optimum output calculation unit 5b decides whether the flow amount set in step S105 is the minimum flow amount which can be set in the pump 4 (step S112). In the embodiment,
20 the maximum flow amount is set at the start of operation in step S105. Therefore, after the first calculation, the process goes to step S113 (No in step S112). The flow amount of the heating medium is decreased for a predetermined stepped size (step S113) and the flow amount after the decrease is set again
25 (step S105). Then, steps S106 to S112 are repeated.

[0043]

In step S112, if the flow amount set in step S105 is the minimum flow amount, step S114 (Yes in step S112) is executed. The optimum calculation output unit 5b compares all the
30 difference values stored by the simulation unit 5c (step S114). After the comparison, the optimum calculation output unit 5b extracts flow amount when the difference is at the minimum, that is, when electric power which can be taken out to the outside is at the maximum, and outputs to the outside (step
35 S115). The output to the outside may be displayed, for example,

on a display and may be directly transmitted to the control unit 5d to control the pump 4. In the embodiment, the output to the outside is directly transmitted to the control unit 5d to control the pump 4.

5 [0044]

<Effect>

According to the solar energy application system 100 above, the suppliable electric power decided based on complex elements can be taken out to the outside at the maximum, the
10 elements being such as the solar insolation amount, the electricity consumption of the pumps and the heat pump and the radiation from the front surface of the solar cell 1 to the outside. Therefore, the solar energy can be used more efficiently.

15 [0045]

In the above explanation, though the circulation of the heating medium is mainly explained, water flow (water supply to the heat pump 3) controlled by the pump 33 is not especially limited. Thus, the pump 33 and the like may be appropriately
20 controlled such that a temperature or storage amount of the water stored in the hot water tank 13 is fulfilled at a desired level.

[0046]

[2. Second embodiment]

25 Next, referring to FIG. 4, a structure of a solar energy application system 200 will be explained. Elements as same as those of the solar energy application system 100 are labeled with same reference numerals and the detailed explanations therefor are omitted.

30 [0047]

The solar energy application system 200 has a heat exchanger 3e in place of the heat pump 3. When the solar energy application system is installed, for example, in a hot area all year around such as a tropical region, a temperature
35 of the heating medium supplied to the heat exchanger 2 remains

hot all year around. Therefore, by directly transmitting solar heat to water in the heat exchanger 3e, the water can be heated adequately and a heat pump is not needed. Thus, by the heat exchanger with less electric consumption than that of the heat pump, electric consumption in the solar energy application system 200 can be restrained.

[0048]

Further, in terms of promoting to cool down the solar cell 1 and increasing electric power generation efficiency of the solar cell 1, a structure may be applied in which the heating medium discharged from the heat exchanger 3e is cooled by a cooler (not illustrated) and the cooled heating medium is supplied to the heat exchanger 2. In this case, the heating medium may be cooled by natural radiation (i.e. heat radiation) instead of cooled by the cooler.

[0049]

In the solar energy application system 200, the same control with the flowchart illustrated in FIG. 3 can be applied.

[0050]

[3. Third embodiment]

Next, referring to FIG. 5, a structure of a solar energy application system 300 will be explained. Elements as same as those of the solar energy system 100 are labeled with same reference numerals and the detailed explanations therefor are omitted. In FIG.5, the hot water tank 13 is illustrated in a horizontally long shape as a matter of space, but is actually in a vertically long shape (being long in a vertical direction).

[0051]

The solar energy application system 300 has temperature sensors 73-78 and 81-84 to measure a temperature at each location. Further, inverter-controlled pumps 32-37 are provided for controlling flow amount of water or heating medium at each location. Still further, flow sensors 92-97 are provided for measuring the flow amount at each location. These elements have same functions as those explained in FIG. 1 and

the explanations therefor are omitted.

[0052]

In the solar energy application system 300, the heating medium discharged from the heat exchanger 2 is temporarily stored in a high temperature heating medium tank 11. The stored heating medium is diverged and is supplied to heat pumps 14, 16 and a heat exchanger 15. After supplying heat to water in the heat pumps 14, 16 and the heat exchanger 15, the heating medium is stored in a low temperature heating medium tank 12. Then, the heating medium stored in the low temperature heating medium tank 12 is resupplied to the heat exchanger 2.

The heat pumps 14 and 16 have a same structure as the heat pump 3 illustrated in FIG. 1. Thus, the explanations therefor are omitted.

15 [0053]

Also in the embodiment, both the heat pump 14 and the heat exchanger 15 are set such that the discharged water temperature therefrom (the temperature measured by the temperature sensors 74 and 76) is at 45 degrees C. Therefore, when the heating medium temperature in the high temperature heating medium tank 11 is equal to or higher than 46 degrees C, the heating medium is supplied to the heat exchanger 15. One example of such a case is that the outdoor temperature measured by, for example, the temperature sensor 79 is high (such as in a summer season, an installation location in the tropical region). On the other hand, when the discharged water temperature is less than at 46 degrees C, the heating medium is supplied to the heat pump 14. Thus, by selecting whether the heating medium should be supplied to the heat pump 14 or the heat exchanger 15 depending on the temperature in the high temperature heating medium tank 11, the water can be heated securely while useless energy consumption can be avoided. A heating medium supply destination is selected by controlling the pumps 32 and 24.

35 [0054]

More specifically, when the heating medium temperature is equal to or higher than a predetermined threshold (46 degrees C in the above example), it is not necessary to increase the heating medium temperature. Therefore, the heating medium is supplied to the heat exchanger 15. On the other hand, when the heating medium temperature is less than the predetermined threshold and heat amount for heating the water (up to 45 degrees C in the above example) is insufficient, the heating medium is supplied to the heat pump 14. Thus, by supplying the heating medium to the heat pump 14 or the heat exchanger 15 depending on the temperature of the heating medium discharged from the heat exchanger 2, the electricity consumption of the heat pump 14 can be reduced. Therefore, the solar energy application system having higher energy efficiency can be provided.

[0055]

When the water temperature at the outlet of the heat exchanger 15 needs to be controlled at 45 degrees C, the flow amount of the heating medium needs to be adjusted. The temperature sensor 76 which measures the temperature of the water discharged from the heat exchanger 15 and the pump 34 are connected to a PID controller 110 via electric lines.

[0056]

Thus, by controlling the pump 34 while measuring the discharged water temperature by the temperature sensor 76, the water can be heated at 45 degrees C. Shortly, when the temperature measured by the temperature sensor 76 is less than 45 degrees C, the flow amount of the heating medium is increased by controlling the pump 34, and when the temperature is more than 45 degrees C, the pump 34 is controlled to reduce the flow amount of the heating medium. Thus, the water can be heated at 45 degrees C for sure.

[0057]

In the solar energy application system 300, the heating medium is also supplied to the heat pump 16. Fluid such as

water flows in an opposite direction to a flow direction of the heating medium. Therefore, the heat pump 16 also exchanges heat as with the heat pump 14, and heat-transferred heating medium is supplied to a fan coil unit 17. Thus, hot air blows from the fan coil unit 17. Shortly, according to the solar energy application system 300, three functions as the electric power supply using the solar light to the outside, the hot water supply and the air heating can be achieved simultaneously. [0058]

The temperature and the flow amount of the water supplied to the heat pump 14 and the heat exchanger 15 is not especially limited and may be set as the solar energy application system 100 described above. Further, each pump, the heat exchangers 2, 15, and the heat pumps 14, 16 and the like may be controlled as same as the solar energy application system 100 already explained in FIG. 3.

[0059]

[4. Variation]

In the third embodiment explained with reference to FIG. 5, the PID controller 110 is used to control the heat exchanger 15. However, the PID controller 110 may be used to control the heat pump 14 or the heat pump 16. Further, the such PID controller 110 may be also provided in the first embodiment illustrated in FIG. 1 and the second embodiment illustrated in FIG. 4. Still further, the heat exchanger 15 may be controlled by a water temperature to be supplied in place of the discharged water temperature. Such structures can bring the same effects. Shortly, supply amount (supply flow amount) of the heating medium may be controlled based on a fluid temperature as heated object such as water.

[0060]

Still further, feedback control or feed forward control other than the PID control may be appropriately applied.

[0061]

Also, in the embodiment, the flow control by the pump 4

is controlled by rotation control with the inverter. Instead of using the inverter, a normal pump and a damper or a flow adjusting valve may be provided to control the flow amount by changing an opening rate of the damper or the flow adjusting valve. Also, in such a case, the flow control corresponds to a "flow amount (circulation amount) control by a circulation pump".

EXPLANATION OF REFERENCES

10 [0062]

- 1 solar cell
- 2 heat exchanger (first heat exchanger)
- 3 heat pump
- 3e heat exchanger (second heat exchanger)
- 15 4 pump (inverter-controlled pump; circulation pump)
- 5 calculation control unit (flow control unit)
- 14 heat pump (one of a pair of heat pumps and a heat exchanger)
- 15 heat exchanger (one of the pair of heat pumps and
- 20 the heat exchanger)
- 16 heat pump
- 100 solar energy application system
- 200 solar energy application system
- 300 solar energy application system

25

CLAIMS

1. A solar energy application system having a solar cell and obtaining electric power by the solar cell comprising:

- 5 a first heat exchanger that cools the solar cell;
a heat pump that is connected to the first heat exchanger;
a circulation pump that circulates a heating medium between the first heat exchanger and the heat pump; and
10 a flow control unit that controls the circulation pump to change circulated amount of the heating medium.

2. The solar energy application system according to claim 1, wherein

- 15 the flow control unit is a calculation control unit that calculates flow amount of the circulating heating medium to control the circulation pump to flow the calculated flow amount, and

the calculation control unit calculates electricity
20 consumption in the solar energy application system and electric power generated by the solar cell, and controls the flow amount of the heating medium by the circulation pump such that difference between the calculated electricity consumption and the generated electric power is set at a maximum.

25

3. A solar energy application system having a solar cell and obtaining electric power by the solar cell comprising:

- a first heat exchanger that cools the solar cell;
a second heat exchanger that is connected to the first
30 heat exchanger;
a circulation pump that circulates a heating medium between the first heat exchanger and the second heat exchanger; and
a flow control unit that controls the circulation pump to
35 change circulated amount of the heating medium.

4. The solar energy application system according to claim 3, wherein

the flow control unit is a calculation control unit that calculates flow amount of the circulating heating medium to control the circulation pump to flow the calculated flow amount, and

the calculation control unit calculates electricity consumption in the solar energy application system and electric power generated by the solar cell, and controls the flow amount of the heating medium by the circulation pump such that difference between the calculated electricity consumption and the generated electric power is set at a maximum.

5. The solar energy application system according to claim 2 or 4, wherein

the calculation control unit calculates radiation amount from the solar cell to an outside and heat exchange amount between the solar cell and the first heat exchanger.

6. The solar energy application system according to either one of claims 1 to 4 further comprising:

a pair of heat pumps and a heat exchanger that are connected in parallel with the first heat exchanger, wherein

either one of the pair of heat pumps or the heat exchanger is supplied with the heating medium based on a temperature of the heating medium discharged from the first heat exchanger.

7. The solar energy application system according to either one of claims 1 to 4, wherein

the flow amount of the heating medium is controlled based on a temperature of fluid as heated object by the heating medium.