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HEAT PUMP TYPE HOT-WATER SUPPLY AIR CONDITIONER

BACKGROUND OF THE INVENTION

The present invention relates to a heat pump type hot-water supply air conditioner and, more particularly, an air conditioner in which a hot-water is supplied through an operation of a heat pump capable of controlling a cooling ability and performance in accordance with a load in an indoor side (i.e. room or room side) while ensuring a suitable hot-water supplying ability.

A conventional heat pump type hot-water supply device has the structure as shown in Fig. 8. A heat pump type hot-water supply device 21 has a refrigerating cycle 22 and is formed by sequentially connecting a compressor 23, a four-way valve 24, a heat exchanger 26 for heating water in a hot-water storing tank 25, a throttle 27, and an outdoor-side heat exchanger 28. In such a heat pump type hot-water supply device 21, when a temperature of the water in the hot water storing tank 25 becomes lower than 30°C, a hot-water storing operation is performed by a heat pump. However, the conventional heat pump type hot-water supply device 21 supplies hot water by using the heat pump, and another refrigerating cycle for cooling the indoor-side (interior of the room) is independently required to be located. Consequently, the exhaust heat of the

refrigerating cycle for cooling the room cannot be used.

As a heat pump type hot-water supply device utilizing an exhaust heat of the refrigerating cycle, Japanese Patent Laid-open Publication No. HEI 11-72268 discloses a heat pump type hot-water supply device for heating water of a hot-water supply circuit by an outdoor-side heat exchanger of a refrigerating cycle and is provided with a structure for preventing the temperature of warm water in a defrosting operation of the refrigerating cycle from being decreased. Such conventional heat pump type hot-water supply device provide a problem such that, since the refrigerating cycle is carried out in a single operation mode, good amenity at the time of a room cooling and hot-water storing operation cannot be realized.

It is therefore required to provide a heat pump type hot-water supply air conditioner which can utilize an exhaust heat of a refrigerating cycle for cooling the room and is operated pleasantly in a room cooling and hot-water storing operation.

SUMMARY OF THE INVENTION

The present invention has been achieved in consideration of the above-described circumstances and its object is to provide a heat pump type hot-water supply air conditioner which can utilize an exhaust heat of a refrigerating cycle for cooling an indoor side (room) and

can be operated pleasantly at the time of the indoor-side (room) cooling and hot-water storing operation.

This and other objects can be achieved according to the present invention by providing a heat pump type hot-water supply air conditioner comprising:

a compressor;

a four-way valve operatively connected to the compressor;

a heat exchanger for heating water connected to the four-way valve;

a flow rate control valve for an outdoor-side heat exchanger connected to the water heating heat exchanger;

an outdoor-side heat exchanger connected at one end thereof to the flow rate control valve for an outdoor-side heat exchanger; and;

a control unit operatively connected to the respective elements mentioned above,

wherein the outdoor-side heat exchanger is connected at another one end thereof to the four-way valve so as to constitute a refrigerating cycle through a refrigerant pipe line and an indoor-side heat exchanger and an indoor-side heat exchanger are further arranged in parallel to the flow rate control valve for the outdoor-side heat exchanger and the outdoor-side heat exchanger, respectively.

In a preferred embodiment, the refrigerating cycle

is operated in three operation modes including a normal cooling operation mode, a cooling and hot-water storing operation mode, and a hot-water storing operation mode which are switched by the control unit, and one of the three operation modes is selected in accordance with presence or absence of a cooling command and a temperature of the water to be supplied.

A rotational speed of the compressor is changed according to a frequency of a power supplied from an inverter connected to the compressor, and when a cooling load is small, a frequency of the compressor is fixed to a predetermined frequency, and when the cooling load is large, the compressor is variable according to the cooling request load of an indoor side.

In the cooling and hot-water storing operation mode, the flow rate control valve for the indoor-side heat exchanger is controlled so that a super-heat condition of the indoor-side heat exchanger becomes constant, and an opening degree of the flow rate control valve for the indoor-side heat exchanger is controlled according to the cooling load of the indoor side.

The hot water is stored in a hot-water tank in which the water heating heat exchanger is disposed and a temperature sensor for detecting a temperature of the hot water in the hot-water tank is provided for the hot-water tank.

According to the present invention of the characters and structures mentioned above, there is provided the heat pump type hot-water supply air conditioner capable of utilizing the exhaust heat of the refrigerating cycle for cooling the interior of the room and being operated pleasantly in the cooling and hot-water storing operation mode.

Specifically, the exhaust heat in the cooling operation mode is utilized to achieve energy saving and, furthermore, the cooling ability can be changed according to the load on the indoor-side (room side) while ensuring the suitable hot-water storing performance. Thus, amenity for people can be also maintained excellent.

Furthermore, the hot-water storage and cooling function can be effectively attained. The real operating frequency of the compressor is forcibly increased to a predetermined value of the frequency, the heat is sufficiently released from the heat exchanger, and the desired hot-water storing ability is realized. Further, even in the case where the cooling load becomes large, the cooling capability in the indoor side will be increased, and hence, the operability conforming with the load can be achieved.

Still furthermore, the balanced operation of the entire refrigerating cycle can be achieved, the heat pump type hot-water supply air conditioner can be operated in a

stable state, the hot water can be surely stored and the amenity of a person in the indoor (room) side can be obtained.

The nature and further characteristic features of the present invention will be made more clear from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a diagram showing a refrigerating cycle for use in a heat pump type hot-water supply air conditioner according to the present invention.

Fig. 2 is a table showing operating modes, in relation to remaining hot water amount, of the heat pump type hot-water supply air conditioner according to the present invention.

Fig.3 is a diagram showing a refrigerating cycle in a normal cooling operation mode of the heat pump type hot-water supply air conditioner according to the present invention.

Fig. 4 is a diagram showing a refrigerating cycle in the cooling and hot-water supplying operation mode of the heat pump type hot-water supply air conditioner according to the present invention.

Fig. 5 is a diagram showing a refrigerating cycle

in the hot-water storing operation mode of the heat pump type hot-water supply air conditioner according to the present invention.

Fig. 6 is a flowchart showing procedure of a subroutine of determining the operating mode of the heat pump type hot-water supply air conditioner according to the present invention.

Fig. 7 is a table showing cross-reference of the operating conditions in the cooling and hot-water storing operation of the heat pump type hot-water supplying air conditioner according to the present invention; and

Fig. 8 is a diagram showing a refrigerating cycle of a conventional heat pump type hot-water supply device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of a heat pump type hot-water supply air conditioner according to the present invention will be described hereunder with reference to the accompanying drawings.

Further, it is to be noted that the term "heat pump type hot-water supply air conditioner" mentioned herein is an air conditioner of the type in which a hot-water is supplied through an operation of a heat pump.

Fig. 1 shows a heat pump type hot-water supply air conditioner 1 provided with a refrigerating cycle 2. The refrigerating cycle 2 is constructed in a manner that a

compressor 4 driven at any rotational speed by an inverter 3, a four-way valve 5 connected on a discharge side 4a of the compressor 4, a heat exchanger 6 for heating water, a two-way valve 7, a flow rate control valve 8 for an outdoor-side heat exchanger (hereinbelow, called an outdoor-side flow rate control valve), and an outdoor-side heat exchanger 9, which is connected to the the four-way valve 5. These elements or members are sequentially connected, in a mentioned order, through a refrigerant pipe line or arrangement to a suction side 4b of the compression 4 so as to realize a refrigerating cycle. A flow rate control valve 10 for an indoor-side (room side) heat exchanger (hereinbelow, called an indoor-side flow rate control valve) and an outdoor-side heat exchanger 11 are further provided in parallel to the outdoor-side flow rate control valve 8 and the outdoor-side heat exchanger 9, respectively.

In the refrigerating cycle 2, by switching the four-way valve 5, a hot-water storing operation is performed by circulating a refrigerant in the direction shown by a solid-line arrow and a normal cooling operation is performed by circulating the refrigerant in the direction shown by a broken-line arrow.

The compressor 4 is connected to the inverter 3 controlled by a controller 12 for controlling the entire arrangement (all the elements or members) of the heat pump

type hot-water supply air conditioner 1 to thereby control the rotational speed of the compressor 4 is controlled. The controller 12 is constructed by a CPU, an input/output interface, a ROM, a RAM, a timer, a counter or like and drives not only the compressor 4 but also the four-way valve 5, an outdoor-side flow rate control valve 8, an indoor-side flow rate control valve 10, an outdoor-side powered fan 9a, an indoor-side powered fan 11a and the like on the basis of input signals from various sensors, change-over switches and the like.

The heat exchanger 6 for heating water is disposed in a hot-water storing tank 14 incorporated in a hot-water supply apparatus 13 to heat water supplied to the hot-water heating tank 14 having a water temperature sensor 14s by the calorie of the refrigerant. Further, the heat exchanger 6 can heat the water to a desired water temperature (hot water temperature) by using the water temperature sensor 14s provided for the hot-water storing tank 14.

Furthermore, each of the outdoor-side flow rate control valve 8 and the indoor-side flow rate control valve 10 is, for example, a powered control valve of which opening degree is controlled by a pulse generated from the controller 12 and controls the flow rate of the refrigerant flowing through the outdoor-side flow rate control valve 8 and the indoor-side flow rate control valve 10.

The outdoor-side heat exchanger 9 is provided with

the outdoor-side powered fan 9a and an outdoor-side heat exchanger sensor 9s, is mounted on the outdoor-side of the room, is operated as an evaporator in the hot-water storing operation mode and operated as a capacitor in the normal cooling operation mode through the operation of the four-way valve 5 or the like. The indoor-side heat exchanger 11 is provided with the indoor-side powered fan 11a and an indoor-side heat exchanger sensor 11s, is mounted on the indoor-side (room-side) and is operated as an evaporator.

A suction sensor 15s is provided for a refrigerant pipe 15 for communicating the suction side 4b of the compressor 4, the outdoor-side heat exchanger 9 and the indoor-side heat exchanger 11.

The heat pump type hot-water supply air conditioner 1 is operated, as shown in Fig. 2, in three modes of a normal cooling operation mode, a cooling and hot-water storing operation mode and a hot-water storing operation mode to be selected in accordance with the presence or absence of a cooling operation command and the quantity of remaining hot water (hot water temperature) in the hot-water storing tank 14.

The operation modes of the heat pump type hot-water supply air conditioner 1 will be described hereunder.

For example, in the normal cooling operation mode, as shown in Fig. 3, the refrigerant in the refrigerating

cycle 2 is operated by repeating a refrigerating cycle of returning to the suction side 4b of the compressor 4 through the discharge side 4a of the compressor 4, four-way valve 5, the outdoor-side heat exchanger 9, the outdoor-side flow rate control valve 8, the indoor-side flow rate control valve 10, the indoor-side heat exchanger 11 and four-way valve 5. In the cooling operation, the refrigerant flowing in the refrigerating cycle 2 is compressed by the compressor 4, condensed and liquified by the outdoor-side heat exchanger 9, decompressed by the indoor-side flow rate control valve 10 and then evaporated by the indoor-side heat exchanger 11 to thereby cool the interior of the room. In the normal cooling operation mode, the refrigerant does not pass the water heating heat exchanger 6 through the operation of the four-way valve 5, so that hot water (water) in the hot-water storing tank 14 is not newly heated.

In the cooling and hot-water storing operation mode, as shown in Fig. 4, the temperature of the water decreases (for example, 45°C or lower) due to the newly supplied water, so that the heating of the water is required. As shown by a solid-line arrow in Fig. 4, a portion of the refrigerant in the refrigerating cycle 2 returns to the suction side 4b of the compressor 4 through the discharge side 4a of the compressor 4, the four-way valve 5, the water heating heat exchanger 6, the two-way

valve 7, the outdoor-side flow rate control valve 8, the outdoor-side heat exchanger 9 and the four-way valve 5. As shown by a dotted line arrow in Fig. 4, the rest of the refrigerant passes through the indoor-side flow rate control valve 10 and the indoor-side heat exchanger 11 and directly returns through the refrigerant pipe 15 to the suction side 4b of the compressor 4 without passing through the four-way valve 5.

In the cooling and hot-water storing operation (in which small amount of the hot water remains), the refrigerant flowing in the refrigerating cycle 2 is compressed by the compressor 4, condensed and liquified by the heat exchanger 6, decompressed by the outdoor-side flow rate control valve 8, evaporated by the outdoor-side heat exchanger 9, further decompressed by the indoor-side flow rate control valve 10 and then evaporated by the indoor-side heat exchanger 11 to thereby cool the interior of the room. Since the small amount of the hot water remains in the hot-water storing tank 14, water is supplied. Consequently, the temperature of the hot water decreases, and it is hence required to heat the hot water to a desired temperature by a heat through the condensation of the refrigerant in the heat exchanger 6.

In the cooling and hot-water storing operation (in which small amount of the hot water remains), when a cooling load of the room side inputted to the controller

12 is small, the frequency of the compressor 4 is forcibly increased to a frequency (50 Hz) at which a sufficient hot-water storing ability or performance is obtained and the compressor 4 is then operated. On the other hand, when the cooling load of the room side becomes large, the compressor 4 is operated in accordance with the magnitude of the load. The indoor-side flow rate control valve 10 is controlled by an output of the controller 12 to make constant a super-heat condition (the temperature difference between the indoor-side heat exchanger sensor 11s and the suction sensor 15s) of the indoor-side heat exchanger 11. The valve opening of the outside flow rate control valve 8 is changed according to the cooling load of the room side inputted to the operation of the controller 12.

Further, in the hot-water storing operation mode, as shown in Fig. 2, although there is no cooling command, a new water supply is required. Moreover, as illustrated in Fig. 5, the refrigent in the refrigerating cycle 2 flows as shown by the arrow in Fig. 5 and returns to the suction side 4b of the compressor 4 through the discharge side 4a of the compressor 4, the four-way valve 5, the water heating heat exchanger 6, the two-way valve 7, the outdoor-side flow rate control valve 8, the outdoor-side heat exchanger 9 and the four-way valve 5. In the hot-water storing operation, the refrigent flowing in the refrigerating cycle 2 is compressed by the compressor 4,

and the hot water is heated by the heat generated through the condensation of the refrigerant in the water heating heat exchanger 6. That is, although the refrigerant passes the heat exchanger 6 through the switching operation of the four-way valve 5 so as to heat the water (to store hot water), the room side (indoor-side) is not cooled. The hot-water storing operation is performed while fixing a real operation frequency of the compressor 4 at 50 Hz.

As described above, the heat pump hot-water supplying air conditioner 1 can operate in the three modes of the normal cooling operation, cooling and hot-water storing operation, and hot-water storing operation selected as shown in Fig. 2 in accordance with the presence/absence of the cooling operation command and the amount of remaining hot water (temperature of hot water) in the hot-water storing tank 14 by the controller 12.

Further, the operation of the heat pump type hot-water supply air conditioner 1 according to the present invention will be described hereunder.

The operation mode of the heat pump type hot-water supply air conditioner 1 is determined according to the procedure shown in Fig. 6.

First, the controller 12 shown in Fig. 1 reads input signals from the indoor-side (room-side) heat exchanger sensor 11s and the water temperature sensor 14s at the step S1 and, thereafter, determines whether the

cooling command is made or not in the step S2. In the case of "YES" in the step S3, it is discriminated whether the temperature of the hot water in the hot-water storing tank 14 detected by the heater temperature sensor 14s is higher than 45°C or not. In the case of "YES", the refrigerating cycle 2 operates in accordance with the normal cooling operation mode. On the other hand, in the case of "NO", the refrigerating cycle 2 operates in the cooling and hot-water storing operation mode.

In the case of "NO" in the step S2, in a manner similar to the step S3, it is discriminated, in the step S4, whether the temperature of the hot water in the hot-water storing tank 14 is higher than 45°C or not. In the case of "YES", the refrigerating cycle 2 does not operate and remains in an operation stopping state. On the contrary, in the case of "NO", the refrigerating cycle 2 operates in the hot-water storing operation mode.

When the normal cooling operation mode is selected in the step S3, as shown in Fig. 3 and described above, the refrigerant does not pass the water heating heat exchanger 6. Consequently, the interior of the room is cooled down and the hot water (water) in the hot-water storing tank 14 is not newly heated.

When the cooling and hot-water storing operation mode is selected in the step S3, as shown in Fig. 4 and described above, in the cooling and hot-water storing

operation (in which the small amount of the hot water remains), it is necessary to cool down the interior of the room and newly supply water. In the cooling and hot-water storing operation (in which the small amount of the hot water remains), the refrigerant flowing in the refrigerating cycle 2 is condensed by the heat exchanger 6 to heat the water in the hot-water storing tank 14 and is then evaporated by the outdoor-side heat exchanger 9 and the indoor-side heat exchanger 11 and the interior of the room is cooled down by the indoor-side heat exchanger 11.

Further, in the cooling and hot-water storing operation (in which the small amount of the hot water remains), when the cooling load is small and the operating frequency becomes low (for example, 30 Hz), as shown in Fig. 7, the real operating frequency of the compressor 4 is forcibly increased to 50 Hz by the controller 12, heat is sufficiently released from the heat exchanger 6 and a high hot-water storing ability is achieved. When the cooling load is large and the operating frequency is higher than 50 Hz, the real operating frequency of the compressor 4 becomes the operating frequency in accordance with the cooling load.

The degree of opening of the outdoor-side flow rate control valve 8 is about 60% (300 pulses) of the full open state (500 pulses). The operational balance of the entire refrigerating cycle 2 is ensured through the control to

make the super-heat condition (temperature difference between the indoor-side heat exchanger sensor 11s and the suction sensor 15s) constant by the indoor-side flow rate control valve 10. Thus, the heat pump type hot-water supply air conditioner 1 can be operated in a stable state. The hot-water storing ability in this operating state can be sufficiently ensured because the operating frequency is forcibly made high. As for the cooling ability or performance for cooling the room, since the opening degree of the outdoor-side flow rate control valve 8 is adjusted to control the flow rate of the refrigerant to the indoor-side, the cooling capability balanced with a load can be realized.

Further, as shown in Fig. 7, when the cooling operation frequency becomes 50 Hz or higher due to a fluctuation in the load, the opening degree of the outdoor-side flow rate control valve 8 becomes 0 (full closed state). The hot-water storing capability at this time is further increased by the increasing in the operating frequency. The refrigerant does not flow to the outdoor-side flow rate control valve 8 as shown by the solid-line arrow in Fig. 4 and flows to the indoor-side heat exchanger 11 as shown by a dotted-line arrow, so that the cooling ability also increases. Thus, the cooling performance corresponding to the load can be realized.

When the hot-water storing operation mode is

selected in the step S4, as shown in Fig. 5' and described above, the compressor 4 operates at a fixed frequency (50 Hz), and the refrigerant flowing in the refrigerating cycle 2 is compressed by the compressor 4 and subjected to the heat exchanging operation with the water through the heat exchanger 6 to heat the water. The refrigerant does not pass the indoor-side heat exchanger 11 and the interior of the room is not therefore cooled. Since the real operating frequency of the compressor 4 is fixed at 50 Hz by the controller 12 in the hot-water storing operation, the sufficient amount of the heat is released from the water heating heat exchanger 6, and the hot-water storing capability is achieved.

Since the exhaust heat in the refrigerating cycle operation is used to store the hot-water (to heat the water) in the operation of the heat pump type hot-water supply air conditioner 1 as described above, the energy saving can be achieved. Further, the cooling ability and performance can be changed according to a load on the indoor-side in the state of the hot-water storing ability being maintained, so that an excellent amenity can be realized. Since the heat pump type hot-water supply air conditioner 1 is operated in the three operating modes of the normal cooling operation, the cooling and hot-water storing operation, and the hot-water storing operation. Therefore, the appropriate mode is selected according to

the presence or absence of a cooling command and the operation under the water-temperature in the hot-water storing tank, so that the hot-water storage and cooling can be efficiently performed.

According to the present invention, as mentioned hereinabove, there can be provided the heat pump type hot-water supply air conditioner which can utilize the exhaust heat of the refrigerating cycle for cooling the interior of the room and can be operated pleasantly in the cooling and hot-water storing operation mode.

CLAIMS

1. A heat pump type hot-water supply air conditioner comprising:
- a compressor;
- 5 a four-way valve operatively connected to the compressor;
- a heat exchanger for heating water connected to said four-way valve;
- a flow rate control valve for an outdoor-side heat exchanger connected to
- the water heating heat exchanger;
- an outdoor-side heat exchanger connected at one end thereof to said
- 10 flow rate control valve ; and;
- a control unit operatively connected to the respective elements
- mentioned above, wherein
- said outdoor-side heat exchanger is connected at another one end
- thereof to the four-way valve so as to constitute a refrigerating cycle through a
- 15 refrigerant pipe line, and an indoor-side heat exchanger and an indoor-side flow
- rate control valve for the indoor-side heat exchanger are further arranged in
- parallel to said outdoor-side heat exchanger and said flow rate control valve for
- the outdoor-side heat exchanger, respectively,
- said refrigerating cycle is operated in three operation modes including a
- 20 normal cooling operation mode, a cooling and hot-water storing operation
- mode, and a hot-water storing operation mode which are switched by the
- control unit, one of said three operation modes being selected in accordance
- with presence or absence of a cooling command and a temperature of the water
- to be supplied, and

rotational speed of the compressor is changed according to an operation command frequency of a power supplied from an inverter connected to the compressor, and when a cooling load is small, a frequency of the compressor is fixed to a predetermined frequency and when the cooling load is large, the
5 compressor is variable according to a cooling load of an indoor side.

2. A heat pump type hot-water supply air conditioner according to claim 1, wherein in the cooling and hot-water storing operation mode, when the cooling load is small, degree of openings of said flow rate control valves of the outdoor-
10 and indoor-side heat exchangers are controlled so that the refrigerant flows in both the outdoor- and indoor-side heat exchangers, and on the other hand, when the cooling load is large, degree of openings of said flow rate control valves of the outdoor- and indoor-side heat exchangers are controlled so that the refrigerant flows only in said indoor-side heat exchanger.

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3. A heat pump type hot-water supply air conditioner according to claim 1, wherein, in said cooling and hot-water storing operation mode, said flow rate control valve for the indoor-side heat exchanger is controlled so that a super-heat condition of the indoor-side heat exchanger becomes constant, and an
20 opening degree of said flow rate control valve for the indoor-side heat exchanger is controlled according to the cooling load of the indoor side.

4. A heat pump type hot-water supply air conditioner according to claim 1, wherein the hot-water is stored in a hot-water tank in which said water heating

heat exchanger is disposed and a temperature sensor for detecting a temperature of the hot water in the hot-water tank is provided for the hot-water tank.