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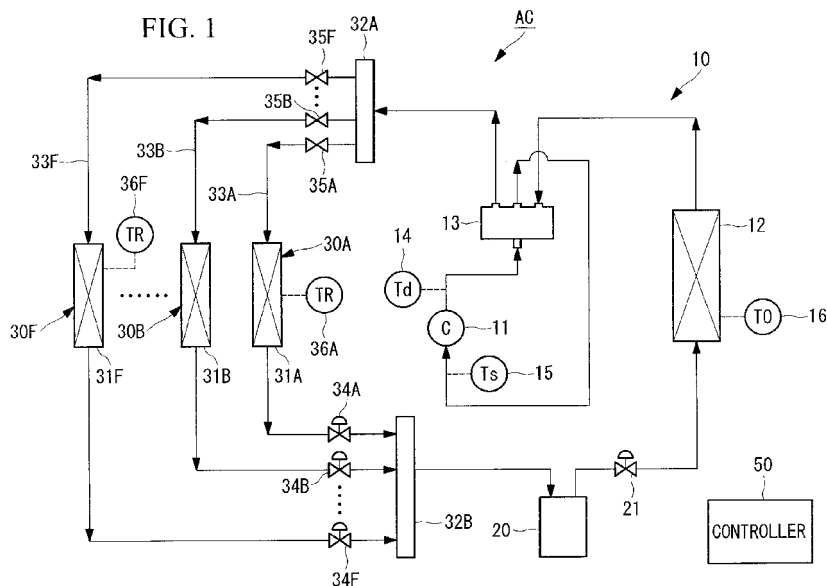
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(54) **Multi-split type air conditioning system**

(57) Provided is a multi-split type air conditioning system AC in which a plurality of indoor units 30 are connected in parallel, and which comprises a receiver 20 installed upstream of an outdoor heat exchanger 12 that serves as an evaporator in heating operation; and an outdoor unit electronic expansion valves 21 installed between the receiver 20 and the outdoor heat exchanger 12, wherein a control unit 50 is provided with an in-heating-operation opening degree control mode for controlling the outdoor unit electronic expansion valve 21, the in-heating-operation opening degree control mode comprising an open-loop control that performs an operation

for a predetermined time period with an outdoor unit electronic expansion valve interim opening degree set corresponding to the actual number of rotation of a variable-power operated type compressor 11 determined by the number of the indoor units 30 being in operation and outdoor air condition; and an outdoor air temperature, a total heat exchange capacity value of the indoor heat exchangers 31, a number of indoor heat exchangers 31 that are stopped, suction superheating and discharge superheating of the variable-power operated type compressor 11 are employed as parameters for calculating the outdoor unit electronic expansion valve interim opening degree.



Description

Technical Field

5 **[0001]** The present invention relates to a multi-split type air conditioning system in which a plurality of indoor units are connected in parallel to one outdoor unit.

Background Art

10 **[0002]** In conventional air conditioner configurations, a plurality of indoor units of one system are connected in parallel to one outdoor unit of the system and operated. Air conditioners of this type are called, for example, multi-split type air conditioning systems (hereafter referred to as multi-split air conditioners).

In such a conventional multi-split air conditioner, each indoor unit has an electronic expansion valve (EEV). By adjusting the aperture (opening degree) of each electronic expansion valve, the multi-split air conditioner appropriately controls the operating point or the amount of refrigerant distribution for each indoor unit.

15 **[0003]** Also, the below-described conventional techniques are known of the control of the amount of refrigerant in the multi-split type air conditioning systems.

A multi-room type air conditioner disclosed in Patent Literature 1 indicated below maintains an appropriate amount of refrigerant circulation according to the number of multiple indoor units being in operation and a refrigerant discharging temperature, to prevent rise in discharging temperature and lack of capacity.

20 **[0004]** The refrigeration cycle disclosed in Patent Literature 2 indicated below prevents refrigerant oil from accumulating inside a refrigeration cycle to lead to oil exhaustion in a compressor, even when the refrigerant oil that is weakly soluble in the refrigerant is used, while avoiding generation of a lot of liquid flowing back to the compressor, even without an accumulator.

25 A method for operating a multi-room type air conditioner disclosed in Patent Literature 3 secures the amount of refrigerant circulation in the refrigeration cycle during a cooling operation by preventing the liquid refrigerant from accumulating in a receiver, thereby enabling an appropriate operation without lack of capacity.

Citation List

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Patent Literature

[0005]

35 {PTL 1}
Japanese Unexamined Patent Application, Publication No. 2002-156166

{PTL 2}
The Publication of Japanese Patent No. 3671850

40 {PTL 3}
Japanese Unexamined Patent Application, Publication No. 2010-210164

Summary of Invention

Technical Problem

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[0006] By the way, in the conventional multi-split type air conditioning systems, when the number of indoor units is increased, for example six indoor units are installed and operated in rooms having different sizes, a difference between the necessary amount of refrigerant in cooling operation and the necessary amount of refrigerant in heating operation (difference between respective necessary refrigerant amounts for cooling and heating) becomes large. Therefore, in the heating operation in which the necessary refrigerant amount is small, surplus refrigerant cannot be appropriately treated. Therefore, such surplus refrigerant accumulates within a heat exchanger inside a room that serves as a condenser. The problem of surplus refrigerant of this kind becomes particularly significant when the six indoor units include one that requires large heat exchange capacity, or more specifically, include a master type one that is for a large space, such as a living room.

55 As stated above, if the surplus refrigerant accumulates at the condenser in the heating operation, the degree of super-cooling at the refrigerant becomes large. In this state, in order to satisfy the performance requirement for heating operation, it is necessary to increase the number of rotation of the inverter-controlled compressor, resulting in an operation in an extremely inefficient operating point.

[0007] With these in the background, it is desired to secure a stable operating point for the rotation rate of an inverter-controlled compressor in the heating operation of the multi-split type air conditioning system by rapidly achieving the optimal operating point, and to improve the efficiency by constructing an operating point with a high Coefficient Of Performance (COP).

The present invention is made to solve the above-described problems, and an object of the present invention is to provide a multi-split type air conditioning system that achieves operation with a high COP by rapidly achieving the optimal operating point in the heating operation to stabilize the number of rotation of the inverter-controlled compressor.

Solution to Problem

[0008] In order to solve the above-described problems, the present invention adopted the following means.
The multi-split type air conditioning system according to present invention comprises:

an outdoor unit including a variable-power operated type compressor, an outdoor heat exchanger and a four-way valve;
a plurality of indoor units including an indoor heat exchanger and an electronic expansion valve and connected in parallel to the outdoor unit;
a control unit that performs various operation control of the plurality of the outdoor unit and the indoor units;
a receiver installed upstream of the outdoor heat exchanger that serves as an evaporator in heating operation; and
an outdoor unit electronic expansion valve installed between the receiver and the outdoor heat exchanger, wherein the control unit is provided with an in-heating-operation opening degree control mode for controlling the outdoor unit electronic expansion valve, the in-heating-operation opening degree control mode comprising an open-loop control that performs an operation when the heating operation is activated and when a number of the indoor units being in operation changes, for a predetermined time period with an outdoor unit electronic expansion valve interim opening degree set corresponding to an actual number of rotation of the variable-power operated type compressor determined by the number of the indoor units being in operation and an outdoor air condition, and
an outdoor air temperature, a total heat exchange capacity value of the indoor heat exchangers, a number of the indoor heat exchangers that are stopped, suction superheating and discharge superheating of the variable-power operated type compressor are employed as parameters for calculating the outdoor unit electronic expansion valve interim opening degree.

[0009] The multi-split type air conditioning system according to the present invention comprises:

a receiver installed upstream of the outdoor heat exchanger that serves as an evaporator in heating operation; and
an outdoor unit electronic expansion valve installed between the receiver and the outdoor heat exchanger, wherein the control unit is provided with an in-heating-operation opening degree control mode for controlling the outdoor unit electronic expansion valve, the in-heating-operation opening degree control mode comprising an open-loop control that performs an operation when the heating operation is activated and when a number of the indoor units being in operation changes, for a predetermined time period with an outdoor unit electronic expansion valve interim opening degree set corresponding to an actual number of rotation of the variable-power operated type compressor determined by the number of the indoor units being in operation and an outdoor air condition, and
an outdoor air temperature, a total heat exchange capacity value of the indoor heat exchangers, a number of indoor heat exchangers that are stopped, suction superheating and discharge superheating of the variable-power operated type compressor are employed as parameters for calculating the outdoor unit electronic expansion valve interim opening degree. Accordingly, it is possible to prevent the surplus refrigerant from accumulating inside the indoor unit heat exchangers that serve as condensers.

Such an in-heating-operation opening degree control mode for controlling the outdoor unit electronic expansion valve is suitable when the plurality of indoor units include a master type one. Particularly, it is suitable for a multi-split type air conditioning system in which five or more indoor units are connected.

[0010] In the above-described multi-split type air conditioning system, the in-heating-operation opening degree control mode performs the open-loop control for a predetermined time period when the heating operation is activated and when the number of the indoor units being in operation changes, and thereafter transits to a zone control, and in the open-loop control for a second or latter time that is initiated after the number of the indoor units being in operation changes, a value obtained by adding a zone control integrated value obtained at a zone control that is performed last time before the open loop control is initiated to a calculated value of the outdoor unit electronic expansion valve interim opening degree. This makes it possible to optimize the outdoor unit electronic expansion valve interim opening degree in the open-loop control for the second or latter time in consideration for the operation state.

Advantageous Effects of Invention

[0011] According to the above-described multi-split type air conditioning system of the present invention, it becomes possible to achieve an operation with a high COP by rapidly achieving the optimal operating point in the heating operation to stabilize the rotation rate of the compressor whose power is variable by inverter control or the like.

Brief Description of Drawings

[0012]

{Fig. 1}

Fig. 1 is a system diagram showing one embodiment of a multi-split type air conditioning system (multi-split air conditioner) according to the present invention, illustrating an exemplary configuration in which the number of indoor units is six.

{Fig. 2}

Fig. 2 is an explanatory diagram showing an example of control of opening degree of an outdoor unit electronic expansion valve (open-loop control and zone control) in heating operation.

Description of Embodiments

[0013] Hereafter, one embodiment of a multi-split type air conditioning system (multi-split air conditioner) according to the present invention will be described based on the drawings. The multi-split air conditioner described hereafter has an exemplary configuration in which six indoor units are connected in parallel. However, the number of indoor units to be connected will not be limited to six.

A multi-split air conditioner AC of an embodiment shown in Fig. 1 has a closed-circuit refrigeration cycle in which six indoor units 30A to 30F are connected in parallel to one outdoor unit 10. This multi-split air conditioner AC comprises a control unit 50 that performs various operation control of the outdoor unit 10 and the indoor units 30A to 30F, and can perform a cooling operation or a heating operation by selecting and switching the direction of flow of the refrigerant circulating in the refrigeration cycle.

Arrows in Fig. 1 show the direction of flow of the refrigerant in a heating operation. In the following descriptions, if there is no need of distinguishing between the six indoor units 30A to 30F and between their associated equipment or the like, the symbols A to F are omitted, so that they are referred to as "indoor units 30".

[0014] The outdoor unit 10 comprises a variable-power operated type compressor (hereafter referred to as "compressor") 11, which is driven by, for example, an inverter-controlled electric motor, an outdoor heat exchanger 12 that performs heat exchange between the refrigerant and the outdoor air, and a four-way valve 13 for performing a cooling operation and a heating operation by selecting and switching the circulation direction of the refrigerant supplied from the compressor 11. The compressor 11 and the four-way valve 13 are configured so that the number of rotation and the direction of refrigerant circulation are controlled by receiving a control signal from the control unit 50.

[0015] On the discharge side of the compressor 11, there is provided a discharge thermal sensor 14 that detects a discharge pipe sensor temperature T_d of the refrigerant. On the suction side of the compressor 11, there is provided a suction thermal sensor 15 that detects a suction pipe sensor temperature T_s of the refrigerant. Also, at an appropriate position of the outdoor heat exchanger 12, there is provided an outdoor heat exchange thermal sensor 16 that detects an outdoor heat exchanging fluid tube sensor temperature T_O .

Temperature detection values (T_d , T_s , T_O) detected respectively by the discharge thermal sensor 14, the suction thermal sensor 15 and the outdoor heat exchange thermal sensor 16 are input to the control unit 50 and used for a variety of operation control.

[0016] The indoor units 30A to 30F comprise indoor heat exchangers 31A to 31F respectively. Each of the indoor units 30A to 30F is provided with refrigerant pipes 33A to 33F that branch out of headers 32A and 32B and are connected thereto in parallel.

The refrigerant pipes 33A to 33F have electronic expansion valves 34A to 34F on one side of the indoor units 30A to 30F and on-off valves 35A to 35F on the other side of the indoor units 30A to 30F. In the illustrated exemplary configuration, the electronic expansion valves 34A to 34F, are installed downstream of the indoor units 30A to 30F in the direction of refrigerant flow in the heating operation, and the on-off valves 35A to 35F are installed upstream thereof.

[0017] In this case, a remotely controllable element, such as a solenoid valve, is used as the on-off valves 35A to 35F. Therefore, the on-off valves 35A to 35F open and close according to the operating/stop state of the indoor units 30 by receiving a control signal from the control unit 50. Further, similarly, the electronic expansion valves 34A to 34F receive individual control signals from the control unit 50 so that the opening degree control is performed.

Moreover, at an appropriate position of the indoor units 30A to 30F, indoor heat exchange thermal sensors 36A to 36F

are provided that detect indoor heat exchanging fluid tube sensor temperature TR of each of the indoor units. Each detection value of the indoor heat exchanging fluid tube sensor temperatures TR detected by the indoor heat exchange thermal sensors 36A to 36F is input to the control unit 50 and used for a variety of operation control.

[0018] Then, the multi-split air conditioner AC of the present embodiment comprises a receiver 20 and an outdoor unit electronic expansion valve 21 upstream of the outdoor heat exchanger 12 that serves as an evaporator in the heating operation. Since the outdoor unit electronic expansion valve 21 in this case is disposed between the receiver 20 and the outdoor heat exchanger 12, the receiver 20 is located upstream of the outdoor unit electronic expansion valve 21 in the direction of refrigerant flow in the heating operation.

[0019] The receiver 20 is a receptacle that has a function to hold surplus refrigerant in heating operation. In other words, the receiver 20 is a receptacle for temporarily reserving liquid refrigerant liquefied in the indoor heat exchanger 31 that serves as a condenser in the heating operation.

The outdoor unit electronic expansion valve 21 is provided for adjusting an operating point of the whole system of the multi-split air conditioner AC, besides the above-described electronic expansion valve 34 for each of the indoor units 30. This outdoor unit electronic expansion valve 21, by performing the aperture control (opening degree adjustment) by receiving from the control unit 50 the control signal on which below-described correction is performed, adjusts surplus refrigerant that accumulates in the receiver 20 disposed upstream of the direction of refrigerant flow in the heating operation. In other words, if the adjustment of the opening degree of the outdoor unit electronic expansion valve 21 is performed in accordance with the state of the heating operation (number of the indoor units 30 being in operation or the like), it is possible to adjust the amount of the liquid refrigerant accumulating in the receiver 20. Therefore it becomes possible to prevent increase of the degree of supercooling caused by the surplus refrigerant accumulation in the indoor units 30.

[0020] The control unit 50 performs a variety of operation control, such as switching between the cooling operation and the heating operation and an operation according to a temperature setting. For example, in the heating operation, the control unit 50 controls the opening degree of the outdoor unit electronic expansion valve 21 (hereafter referred to as "EEVH opening degree"), in the manner as shown in Fig. 2.

The EEVH opening degree in the heating operation is adjusted by an in-heating-operation opening degree control mode provided in the control unit 50. In other words, in the heating operation, an eventual operating point of the EEVH opening degree is determined by the open-loop control and the zone control.

[0021]

(1) In the open-loop control, there is calculated the EEVH opening degree corresponding to the actual number of rotation (N) of the compressor 11 determined by the number of the indoor units 30 being in operation and external temperature conditions, and a roughly determined operating point is set.

(2) In the zone control, by controlling the operating point of the EEVH opening degree to achieve a discharge superheating TDSH corresponding to the actual number of rotation (N) of the compressor 11, the operating point is eventually transited to such one that meets a dilution ratio and a working pressure restriction of the compressor 11.

The open-loop control and the zone control are disclosed in, for example, Japanese Examined Utility Model Application, Publication No. Hei7-14772, Japanese Unexamined Patent Application, Publication No. 2003-106608 and Japanese Unexamined Patent Application, Publication No. 2003-130426.

[0022] In other words, the in-heating-operation opening degree control mode comprises an open-loop control that performs an operation when the heating operation is activated and when a number of the indoor units being in operation changes, for a predetermined time period with an outdoor unit electronic expansion valve interim opening degree set corresponding to the actual number of rotation (N) of the compressor 11 determined by the number of the indoor units 30 being in operation and the outdoor air condition. This open-loop control employs an outdoor air temperature, a total heat exchange capacity value of the indoor heat exchangers 31, the number of indoor heat exchangers 31 that are stopped, a suction superheating SH and discharge superheating TDSH of the compressor 11 as parameters for calculating the outdoor unit electronic expansion valve interim opening degree.

Then, after the operation by the open-loop control for a predetermined time period with the outdoor unit electronic expansion valve interim opening degree, the mode transits to the zone control that controls the operating point to the discharge superheating TDSH corresponding to actual number of rotation (N) of the compressor 11. This zone control is continued until a change occurs in the number of the indoor units 30 being in operation.

[0023] Here, a description will be given of one example of the EEVH opening degree control for the in-heating-operation opening degree control mode shown in Fig. 2.

This control mode includes an open-loop control and a zone control, and in the shut-down state of the multi-split air conditioner AC, the EEVH opening degree is in the initial condition in which the EEV is full open. When the multi-split air conditioner AC is activated from the initial condition, initially, an outdoor unit electronic expansion valve interim opening degree R1 is calculated by the open-loop control. In the open-loop control, the opening degree is fixed to the calculated

outdoor unit electronic expansion valve interim opening degree R1, and the heating operation is continued until a pre-determined time (for example, 3 minutes or so) elapses.

[0024] In the present embodiment, the opening degree (OP) of the outdoor unit electronic expansion valve is calculated as the outdoor unit electronic expansion valve interim opening degree R1 by correcting the actual number of rotation

(N) of the compressor 11 based on the below-indicated formula at the open-loop control in the heating operation. In the below-indicated formula, correction coefficients a, b according to the external temperature, and the heat exchange capacity, and a correction coefficient Z_4 determined based on the presence or absence of the master type indoor unit and the total value of the capacities of the heat exchangers, are newly added correction coefficients. In other words, that part of the formula to calculate opening degree of the outdoor unit electronic expansion valve, in which the other

[0025] Electronic expansion valve opening degree EEVH OP = $(a \times N + b + c) \times Z_2 \times Z_3 \times Z_4$

where a, b are correction coefficients based on the external temperature and the heat exchange capacity;

c is the sum of α pulses of all of the stop units;

Z_2 is a correction coefficient for retaining appropriate suction superheating of the whole of the system, which particularly aims at stabilizing the open-loop control in the transit period;

Z_3 is a correction coefficient for retaining appropriate discharge superheating of the whole of the system;

Z_4 is a correction coefficient determined by the presence or absence of the master type indoor unit and the total value of the capacities of the heat exchangers (see values in Table 5); and

N is an actual number of rotation of the compressor (where a value rounded off to the closest whole number is used for calculating the opening degree).

[0026] Table 1 and Table 2 show examples of correction coefficients a, b selected based on the outdoor air temperature and the total value of the capacities of the heat exchangers. Correction coefficients a, b used at the open-loop control in the heating operation are, for example, as illustrated in Table 1 and Table 2, determined based on the total value of the heat exchanger capacities of the indoor units 30 that are connected (total value of the capacities of the heat exchangers that serve as condensers) and the outdoor air temperature. The correction coefficient a illustrated in Table 1 and the correction coefficient b illustrated in Table 2 are predetermined values determined based on experiments or the like.

Table 1

		Total value of capacities of heat exchangers			
		~300	301~400	401~500	501~
Outdoor air temperature	A	0.9	1.1	1.4	1.5
	B	0.7	0.8	1.0	1.2
	C	0.5	0.6	0.8	1.0
	D	0.3	0.4	0.6	0.8

Table 2

		Total value of capacities of heat exchangers			
		~300	301~400	401~500	501~
Outdoor air temperature	A	60	70	80	90
	B	55	60	65	70
	C	50	55	55	60
	D	45	45	50	50

[0027] Table 3 shows one example of heat exchange performance capacities determined for respective indoor units. The above-described total value of the capacities of the heat exchangers of the indoor units 30 is calculated by using for example, performance values illustrated in Table 3. The heat exchanger capacities illustrated in Table 3 are values of a variety of indoor heat exchangers 31 installed in a variety of indoor units 30. In Table 3, heat exchanger capacity proportions for respective types of shape (EXT-1 to 4) are shown by being listed in columns, for each of model-specific capacities (EXD-1 to 4) listed in rows, with a reference model-specific capacity being assumed to be 100. In this case, the model-specific capacities in the rows mean, for example, performances required for indoor heat exchangers 31 for use in rooms with a variety of capacities, such as a room with a small capacity of space, e.g. a child's room, and a living room with a large capacity of space. Furthermore, types of shape in the columns mean that the heat exchanger capacity proportion varies depending on the installation structure of the indoor units 30 such as wall-hanging type, ceiling-mounted type and free-standing type, even with the same model-specific capacity.

Table 3

Types of shape	Model-specific capacity	EXD-1	EXD-2	EXD-3	EXD-4
EXT-1		100	100	100	—
EXT-2		63	63	63	—
EXT-3		77	97	97	—
EXT-4		—	—	—	125

[0028] Hereafter, calculation of the total value of the capacities of the heat exchangers by using Table 3 will be described by showing one example.

Here, it is assumed that six indoor units 30 are connected to the multi-split air conditioner AC. The details are as follows: there are three indoor units with a model-specific capacity of EXD-1 and a type of shape EXT-1; two indoor units with

a model-specific capacity EXD-2 and a type of shape EXT-2; and one indoor unit with a model-specific capacity EXD-4 and a type of shape EXT-4. In this case, according to Table 3, the heat exchanger capacity proportion of the indoor units with the model-specific capacity of EXD-1 and the type of shape EXT-1, which is the reference model, is 100; the heat exchanger capacity proportion of the indoor units with the model-specific capacity of EXD-2 and the type of shape EXT-2 is 63; and the heat exchanger capacity proportion of the indoor unit with the model-specific capacity of EXD-4 and the type of shape EXT-4 is 125.

[0029] Therefore, the total value of the capacities of the heat exchangers in this case is calculated according to the below-indicated formula.

$$\begin{aligned} \text{Total value of capacities of heat exchangers} &= (100 \times 3) \\ &+ 63 + 125 = 488 \end{aligned}$$

By the way, the above-described indoor unit with the model-specific capacity EXD-4 and the type of shape EXT-4 is what is called a master type, being for use in a large space, such as a living room. For such a master type indoor unit, since the heat exchanger therein is constituted by multiple circuits, the value of heat exchanger capacity proportion is set to be equal to or greater than the reference value 100. That is, since a master type indoor unit has a heat exchanger with multiple circuits, lowering of refrigerant flow rate causes a longer passage time of the refrigerant. Therefore, it is necessary to raise the refrigerant flow rate by setting an increased heat exchanger capacity proportion in order to prevent the refrigerant from being held.

[0030] Next, the correction coefficient c used in the open-loop control in the heating operation is determined in the manner described below. Table 4 shows one example of a correction pulse α necessary for determining the correction coefficient c .

Initially, the correction pulse α is determined according to the heat exchanger capacity proportion of one indoor unit 30 being in the shut-down state for example, in the manner as illustrated in Table 4. After that, for all indoor units 30 being in the shut-down state, correction pulses α determined according to Table 4 are summed to yield the correction coefficient c .

Table 4

Heat exchanger capacity proportion of indoor exchanger being in shut-down state	~90	91~110	111~
α	3	5	10

[0031] One specific example is shown below. For example, where one indoor unit 30 with the model-specific capacity EXD-1 and the type of shape EXT-1 and another one indoor unit with the model-specific capacity EXD-2 and the type of shape EXT-2, the indoor unit 30 with the model-specific capacity EXD-1 and the type of shape EXT-1 has a heat exchanger capacity proportion of 100. Therefore, correction pulse α is 5. The indoor unit 30 with the model-specific capacity EXD-2 and the type of shape EXT-2 has a heat exchanger capacity proportion of 63. Therefore, the correction pulse α is 3. Accordingly, because the correction coefficient c is a sum total of the correction pulses α , it is the total value of the correction pulse α ($= 5$) and the correction pulse α ($= 3$), that is, 8 ($c = 5 + 3$).

[0032] The correction coefficient Z_2 is a value for retaining an appropriate suction superheating SH in the whole of the multi-split air conditioner AC, and this is a correction value that has been used also in the conventional control techniques. The correction coefficient Z_2 is a value determined according to a temperature difference ($SH = T_s - T_O$) between the suction pipe sensor temperature T_s and the outdoor heat exchanging fluid tube sensor temperature T_O .

In other words, during the transition operation in which the compressor 11 is activated or the number of the indoor units 30 being in operation changes, the suction superheating SH is equal to or greater than the discharge superheating TDSH, and moreover, the suction superheating SH fluctuates earlier. Therefore, a control is performed to correct the opening degree (OP) of the outdoor unit electronic expansion valve by determining the correction coefficient Z_2 with the suction superheating SH being used as the parameter.

[0033] The correction coefficient Z_3 is a value for retaining an appropriate discharge superheating TDSH in the whole of the multi-split air conditioner AC, and this is a correction value that has been used also in the conventional control techniques. The correction coefficient Z_3 is a value determined according to a temperature difference ($TDSH = T_d - T_R$) between discharge pipe sensor temperature T_d and the indoor heat exchanging fluid tube sensor temperature T_R . As the indoor heat exchanging fluid tube sensor temperature T_R in this case, the highest temperature (maximum value) from among the indoor units 30 performing the heating operation is used.

In other words, since at the cryogenic temperature the discharge superheating TDSH is difficult to achieve and the liquid

tends to flow back, it becomes difficult to stabilize the oil level of the compressor 11. Then, in order to expedite convergence to an appropriate operating point, the correction coefficient Z_3 is determined with the discharge superheating TDSH as a parameter to perform a control to correct the opening degree (OP) of the outdoor unit electronic expansion valve.

[0034] The correction coefficient Z_4 is a correction coefficient determined based on the presence or absence of the master type (the type shown in Table 3 with the model-specific capacity EXD-4 and the type of shape EXT-4) and the above-described total value of the capacities of the heat exchangers, and is determined in the manner shown in, for example, Table 5. Table 5 shows one example of the correction coefficient Z_4 that varies depending on the conditions. In the example shown in Table 5, where the connected units of the indoor units 30 do not include any master type one, the correction coefficient Z_4 is set to be 1.0 and the correction is thereby not performed.

However, where a master type indoor unit 30 is included, the correction coefficient Z_4 is provided that varies depending on whether the total value of the capacities of the heat exchangers calculated using Table 3 is equal to or greater than a predetermined value (for example 400). In the example shown in Table 5, where the calculated total value of the capacities of the heat exchangers is less than 400, the correction coefficient Z_4 is set to be 1.3, and where the calculated total value of the capacities of the heat exchangers is equal to or greater than 400, the correction coefficient Z_4 is set to be 1.5.

Table 5

	Total value of capacities of heat exchangers	Z_4
Where connected units do not include master type	—	1.0
Where connected units include master type	~399	1.3
	400~	1.5

[0035] When each correction coefficient, a, b, c, Z_2 , Z_3 , Z_4 is determined in this way, the actual number of rotation (N) of the compressor 11 is corrected based on the above-described formula, and the opening degree (OP) that is to be outdoor unit electronic expansion valve interim opening degree R1 of the outdoor unit electronic expansion valve 21 in the open-loop control in the heating operation is calculated.

Thus-calculated outdoor unit electronic expansion valve interim opening degree R1 of the outdoor unit electronic expansion valve 21 is kept as-is after being set and the operation continues until a predetermined operating time elapses. After that, the mode transits to the zone control, and the zone control is continued until a change occurs in the number of the indoor units 30 being in operation. In other words, by controlling the operating point of the EEVH opening degree to achieve the discharge superheating TDSH corresponding to the actual number of rotation (N) of the compressor 11, the zone control is continued to transit eventually to an operating point that meets the dilution ratio and the working pressure restriction of the compressor 11.

[0036] After a change occurs in the number of the indoor units 30 being in operation, the mode transits again to the open-loop control. Also in this open-loop control, the opening degree (OP), which is to be outdoor unit electronic expansion valve interim opening degree R2 after the number of the indoor units 30 being in operation changes, is calculated by performing correction based on the formula that is the same as the above-described correction performed after the activation.

However, the outdoor unit electronic expansion valve interim opening degree R_r set after the number of the indoor units being in operation changes is a value ($R_r = R_2 + \Delta R$) in which the last zone control integrated value ΔR is added to the calculated outdoor unit electronic expansion valve interim opening degree R2. In other words, the opening degree of the outdoor unit electronic expansion valve 21 to actually be set is the outdoor unit electronic expansion valve interim opening degree R_r that is a value in which the state of operation before the change in the number of the indoor units being in operation occurred is reflected. After the heating operation is continued with the opening degree being fixed to this value for a predetermined time period, the mode transits again to the above-described zone control.

[0037] In this way, when the multi-split air conditioner AC is activated to initiate heating operation, the control of opening

degree of the outdoor unit electronic expansion valve 21 is performed such that, after the operation is continued for a predetermined time period with the outdoor unit electronic expansion valve interim opening degree R1 being set in the initial open-loop control, the zone control and the open-loop control are repeated until shut-down. Then, in the open-loop control for the second or latter time initiated after the number of the indoor units being in operation changes, an outdoor unit electronic expansion valve interim opening degree is set to be a value R_r ($R_r = R_n + \Delta R$), which is obtained by adding the zone control integrated value ΔR of the last zone control before the initiation of the open-loop control, that is, the zone control integrated value ΔR immediately before the change in the number of indoor units being in operation to the outdoor unit electronic expansion valve interim opening degree R_n ($n \geq 2$) calculated at the newly initiated open-loop control.

[0038] In this way, by employing the outdoor unit electronic expansion valve interim opening degree R_r obtained by adding the zone control integrated value ΔR of the last zone control before the initiation of the open-loop control to the calculated value R_n of the outdoor unit electronic expansion valve interim opening degree, in the open-loop control for the second or latter times initiated after the number of the indoor units being in operation changes, it becomes possible to set an opening degree optimized in consideration for the operation state of the multi-split air conditioner AC. Thereby, it becomes possible to reduce the time needed for constructing an optimal operating point.

In this stage, since in each of the indoor units 30 being in the heating operation, the amount of required refrigerant distribution of the indoor heat exchangers 31 is different for each of the indoor units 30, controlling the electronic expansion valves 34 according to the required number of rotation of the compressor for each indoor unit 30 makes it possible to rapidly construct an optimal operating point for each electronic expansion valve 34.

[0039] Performing such an EEVH opening degree control for an in-heating-operation opening degree control mode makes it possible to secure a stable operating point for the number of rotation of the compressor 11 driven by an inverter-controlled electric motor, construct an operating point with a high COP and improve the efficiency of the system by rapidly achieving the optimal operating point in heating operation of the multi-split air conditioner AC.

Furthermore, in the above-described zone control, it is desirable to set the degree of opening (aperture) of the outdoor electronic expansion valve 21 to be a sampling time in accordance with the fluid delivery rate characteristic of the outdoor electronic expansion valve 21. That is, if variation of the fluid delivery rate characteristic of the electronic expansion valve 21 is large, it becomes possible to stabilize the refrigerant behavior by shortening the sampling time.

[0040] The above-described in-heating-operation opening degree control mode of the present embodiment is suitable when the plurality of indoor units include a master type one, and particularly, it is suitable for a multi-split air conditioner AC in which five or more indoor units 30 are connected in parallel.

The present invention is not limited to the above-described embodiment. Modifications may be appropriately made within the scope of the present invention without departing from the gist of the present invention.

Reference Signs List

[0041]

10	outdoor unit
11	variable-power operated type compressor (compressor)
12	outdoor heat exchanger
13	four-way valve
14	discharge thermal sensor
15	suction thermal sensor
16	outdoor heat exchange thermal sensor
20	receiver
21	outdoor unit electronic expansion valve
30 (30A to 30F)	indoor unit
31 (31A to 31F)	indoor heat exchanger

32A, 32B	header
33 (33A to 33F)	refrigerant pipe
5 34 (34A to 34F)	electronic expansion valve
35 (35A to 35F)	on-off valve
36 (36A to 36F)	indoor heat exchange thermal sensor
10 50 control	unit
AC	multi-split type air conditioning system (multi-split air conditioner)

Claims

1. A multi-split type air conditioning system comprising:

an outdoor unit including a variable-power operated type compressor, an outdoor heat exchanger and a four-way valve;
 a plurality of indoor units including an indoor heat exchanger and an electronic expansion valve and connected in parallel to the outdoor unit;
 a control unit that performs various operation control of the outdoor unit and the indoor units;
 a receiver installed upstream of the outdoor heat exchanger that serves as an evaporator in heating operation; and
 an outdoor unit electronic expansion valve installed between the receiver and the outdoor heat exchanger, wherein
 the control unit is provided with an in-heating-operation opening degree control mode for controlling the outdoor unit electronic expansion valve, the in-heating-operation opening degree control mode comprising an open-loop control that performs an operation when the heating operation is activated and when a number of the indoor units being in operation changes, for a predetermined time period with an outdoor unit electronic expansion valve interim opening degree set corresponding to an actual number of rotation of the variable-power operated type compressor determined by the number of the indoor units being in operation and an outdoor air condition, and an outdoor air temperature, a total heat exchange capacity value of the indoor heat exchangers, a number of the indoor heat exchangers that are stopped, suction superheating and discharge superheating of the variable-power operated type compressor are employed as parameters for calculating the outdoor unit electronic expansion valve interim opening degree.

2. The multi-split type air conditioning system according to claim 1, wherein

the in-heating-operation opening degree control mode performs the open-loop control for a predetermined time period when the heating operation is activated and when the number of the indoor units being in operation changes, and thereafter transits to a zone control, and
 in the open-loop control for a second or latter time that is initiated after the number of the indoor units being in operation changes, a value obtained by adding a zone control integrated value obtained at a zone control that is performed last time before the open loop control is initiated to a calculated value of the outdoor unit electronic expansion valve interim opening degree.

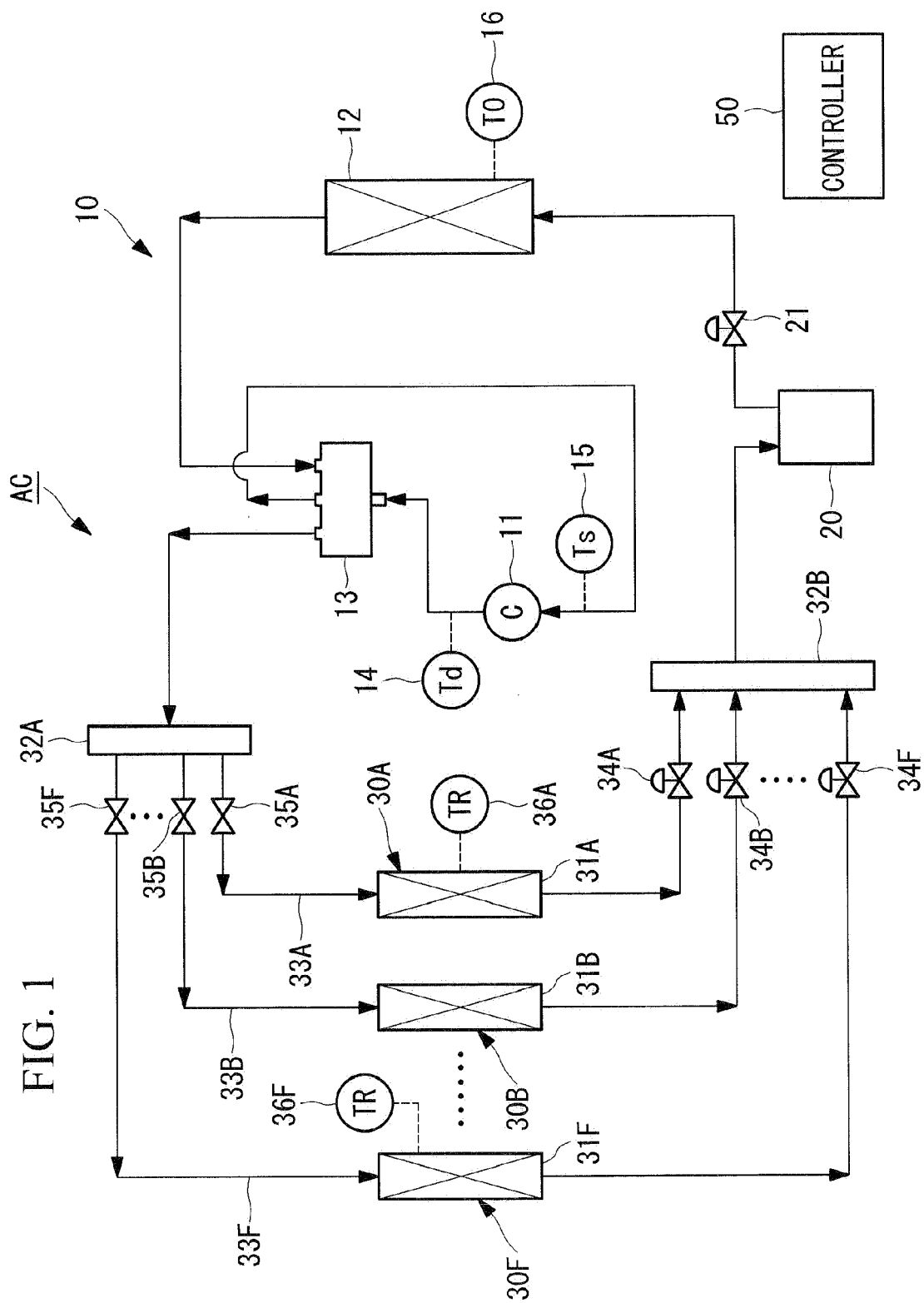
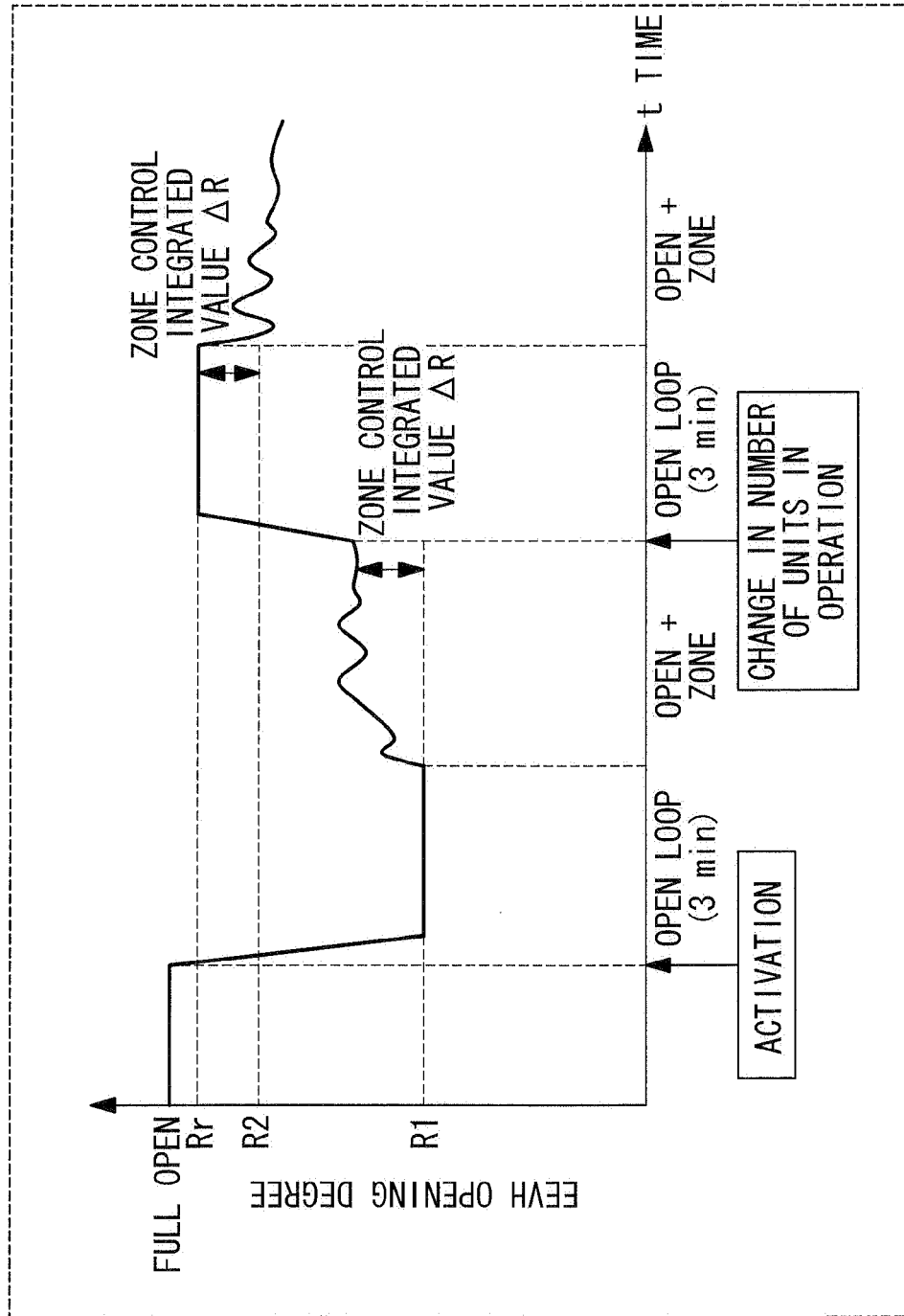


FIG. 2



REFERENCES CITED IN THE DESCRIPTION

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