

DESCRIPTION

Title of the Invention

AIR-CONDITIONING SYSTEM AND AIR-CONDITIONING METHOD

5 Technical Field

[0001] The present invention relates to an air-conditioning system having an air-conditioning core unit in which wet channels which cause a vaporization phenomenon, and dry channels which pass air to be cooled are formed through a partition member, and an air-conditioning method.

10 Background Art

[0002] Humidifying the air causes a vaporization phenomenon and deprives the latent heat, so that the temperature of the air is cooled to the wet-bulb temperature of the air. However, the air to be cooled is humidified simultaneously. This principle has been widely known as humidification cooling, and a vaporizing cooler using the same has also
15 been widely produced and sold. In the case where it is not desired to humidify air to be released, a method of separating a humidified and cooled zone (wet channel) and a zone (dry channel) through which the air to be cooled passes, transferring a temperature cooled in the humidified and cooled zone to the zone of air to be cooled by heat exchange, and cooling only the sensible heat of the air in the zone of air to be cooled, so-called indirect
20 vaporization cooling is performed (refer to, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent No. 4565417
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Summary of Invention

Technical Problem

[0004] A problem however arises in that a theoretical lower limit value exists in a coolable temperature because a natural phenomenon of water vaporization is used in the
30 case of the vaporization cooling, and a difficulty occurs in cooling the temperature to below

the theoretical lower limit value. There has therefore been desired the development of a new system capable of efficiently performing comfortable air conditioning by combination with other system.

[0005] The present invention has been made based on such problems, and it is an object of the present invention to provide an air-conditioning system and an air-conditioning method capable of efficiently performing comfortable air conditioning.

Solution to Problem

[0006] An air-conditioning system according to claim 1 includes a total heat exchanger which exchanges heat between indoor air and outdoor air, an air-conditioning core unit having a wet channel which causes a vaporization phenomenon, and a dry channel passing air to be cooled both being formed through a water-impermeable partition member provided with a wetting layer holding water on the side of the wet channel, an air supply flow passage which guides the outdoor air to the dry channel of the air-conditioning core unit after guiding the outdoor air to the total heat exchanger to supply the outdoor air indoors, an exhaust flow passage having a first exhaust flow passage capable of after guiding the indoor air to the total heat exchanger, guiding at least part of the indoor air having passed through the total heat exchanger to the wet channel of the air-conditioning core unit to exhaust the indoor air outdoors, and a second exhaust flow passage capable of exhausting at least the part of the indoor air having passed through the total heat exchanger outdoors without being guided to the wet channel of the air-conditioning core unit, an outdoor air flow passage capable of guiding the outdoor air to the wet channel of the air-conditioning core unit to exhaust the outdoor air outdoors, an air supply fan which supplies the outdoor air through the air supply flow passage, an exhaust fan which exhausts the indoor air through the exhaust flow passage, and an outdoor air circulating fan which causes the outdoor air to be circulated in the wet channel through the outdoor air flow passage.

[0007] An air-conditioning system according to claim 2 is provided in which in the air-conditioning system according to claim 1, a heat pump having an evaporator which decompresses a heating medium to thereby lower the temperature to absorb heat, and a condenser which pressurizes the heating medium to thereby raise the temperature to

generate heat is provided, and the evaporator or the condenser is arranged on the downstream side having passed through the dry channel of the air-conditioning core unit in the air supply flow passage.

[0008] An air-conditioning method according to claim 5 is provided which comprises

5 the steps of, using the air-conditioning system according to claim 1: in the case where an outdoor temperature or enthalpy is higher than indoors during cooling, operating a total heat exchange function of the total heat exchanger, allowing at least part of the indoor air having passed through the total heat exchanger to be circulated in the wet channel of the air-conditioning core unit, supplying water to the wetting layer of the wet channel to cool
10 the partition member by the vaporization phenomenon in the wet channel, and cooling the outdoor air having passed through the total heat exchanger and guided to the dry channel by the heat exchange so as to be supplied indoors; and in the case where an indoor temperature or enthalpy is higher than outdoors during cooling, stopping the total heat change function of the total heat exchanger, exhausting the indoor air having passed
15 through the total heat exchanger outdoors without being guided to the wet channel of the air-conditioning core unit, allowing the outdoor air to be circulated in the wet channel, supplying water to the wetting layer of the wet channel to cool the partition member by the vaporization phenomenon in the wet channel, and cooling the outdoor air having passed through the total heat exchanger and guided to the dry channel by the heat
20 exchange so as to be supplied indoors.

[0009] An air-conditioning method according to claim 7 is provided which comprises

the steps of, using the air-conditioning system according to claim 2, during cooling, cooling the outdoor air having passed through the dry channel by the evaporator of the heat pump so as to be supplied indoors, and during heating, heating the outdoor air having
25 passed through the dry channel by the condenser of the heat pump so as to be supplied indoors.

Advantageous Effects of the Invention

[0010] According to the present invention, a total heat exchanger and an air-conditioning
30 core unit are combined to enable outdoor air heat-exchanged by the total heat exchanger to

pass through a dry channel of the air-conditioning core unit. Therefore, for example, in summertime during which an outdoor temperature or enthalpy is higher than indoors, the total heat exchanger performs heat exchange between hot outdoor air and cold indoor air to lower the temperature of the outdoor air, and thereafter the air-conditioning core unit is capable of supplying water to a wetting layer of a wet channel to cool the outdoor air in the dry channel by a vaporization phenomenon in the wet channel. Further, since it is possible to circulate at least part of the indoor air having passed through the total heat exchanger in the wet channel of the air-conditioning core unit, the temperature can be lowered by reusing the exhaust lower in temperature than the outdoor air. It is thus possible to efficiently cool the outdoor air.

[0011] Also, for example, in an intermediate period during which an indoor temperature or enthalpy is higher than outdoors, the temperature can be lowered using cold outdoor air if the total heat exchanger is stopped to guide the outdoor air to the wet channel. Thus, even in the case where at night in summer, or in spring and autumn or the like, the indoor temperature becomes higher than the outdoor temperature, and it is desired to lower the indoor temperature, it can be cooled efficiently.

[0012] Further, if an evaporator or a condenser in a heat pump is arranged on the downstream side of the dry channel in an air supply flow passage, the outdoor air cooled by the air-conditioning core unit can be further cooled by the evaporator. In addition, the outdoor air heat-exchanged by the total heat exchanger can be further heated by the condenser. It is thus possible to efficiently perform cooling and heating as compared with the case where the cooling and heating are performed only by the heat pump.

[0013] Additionally, if the evaporator of the heat pump is arranged on the downstream side having passed through the dry channel of the air-conditioning core unit in an air supply flow passage, and the condenser is arranged on the downstream side having passed through the total heat exchanger in an exhaust flow passage, or the condenser is arranged on the downstream side having passed through the dry channel of the air-conditioning core unit in the air supply flow passage, and the evaporator is arranged on the downstream side having passed through the total heat exchanger in the exhaust flow passage, during cooling, the condenser can be cooled by using the exhaust having passed through the total heat

exchanger which is lower in temperature than the outdoor air, and during heating, the evaporator can be heated by using the exhaust having passed through the total heat exchanger which is higher in temperature than the outdoor air. Thus, it is possible to improve the efficiency of the heat pump and achieve energy saving as compared with the case where the outdoor air is utilized.

Brief Description of Drawings

[0014] FIG. 1 is diagram showing a schematic configuration of an air-conditioning system according to a first embodiment of the present invention.

FIG. 2 is a cross-sectional diagram showing a configuration of an air-conditioning core unit taken along line II-II shown in FIGS. 3 and 4.

FIG. 3 is a cross-sectional diagram showing a configuration of the air-conditioning core unit taken along line III-III shown in FIG. 2.

FIG. 4 is a cross-sectional diagram showing a configuration of the air-conditioning core unit taken along line IV-IV shown in FIG. 2.

FIG. 5 is a diagram showing a schematic configuration of the air-conditioning system shown in FIG. 1 during heating.

FIG. 6 is a diagram showing a schematic configuration of the air-conditioning system shown in FIG. 1 during cooling.

FIG. 7 is another diagram showing the schematic configuration of the air-conditioning system shown in FIG. 1 during cooling.

FIG. 8 is a flow diagram showing the operation of the air-conditioning system shown in FIG. 1.

FIG. 9 is a diagram showing a result of simulation where cooling is performed using the air-conditioning system shown in FIG. 6.

FIG. 10 is a diagram showing a result of another simulation where cooling is performed using the air-conditioning system shown in FIG. 7.

FIG. 11 is a diagram showing a result of simulation where heating is performed using the air-conditioning system shown in FIG. 5.

FIG. 12 is a diagram showing a schematic configuration of an air-conditioning

system according to a second embodiment of the present invention.

FIG. 13 is another diagram showing the schematic configuration of the air-conditioning system shown in FIG. 12.

5 Description of Embodiments

[0015] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

[0016] (First embodiment)

10 FIG. 1 shows a schematic configuration of an air-conditioning system 1 according to a first embodiment of the present invention. FIGS. 2 through 4 respectively show the configuration of an air-conditioning core unit 20 shown in FIG. 1. Incidentally, FIG. 2 is a cross-sectional diagram taken along line II-II shown in FIGS. 3 and 4, FIG. 3 is a cross-sectional diagram taken along line III-III shown in FIG. 2, and FIG. 4 is a cross-sectional diagram taken along line IV-IV shown in FIG. 2.

15 [0017] The air-conditioning system 1 includes, for example, a total heat exchanger 10 which heat-exchanges between indoor air and outdoor air, an air-conditioning core unit 20 capable of performing indirect vaporization cooling, a heat pump 30, an air supply flow passage 40 which guides the outdoor air to be supplied indoors, an exhaust flow passage 50 which guides the indoor air to be exhausted outdoors, an outdoor air flow passage 60
20 capable of guiding the outdoor air to the air-conditioning core unit 20 to exhaust the same outdoors, an air supply fan 71 which supplies the outdoor air through the air supply flow passage 40, an exhaust fan 72 which exhausts the indoor air through the exhaust flow passage 50, an outdoor air circulating fan 73 which causes the outdoor air to be circulated in the air-conditioning core unit 20 through the outdoor air flow passage 60, and a control
25 unit 80 which controls their operations.

[0018] The total heat exchanger 10 is used to exchange and recover the total heat (sensible heat and latent heat) of air-conditioning energy lost by ventilation. The total heat exchanger 10 is preferably rotary. This is because a total heat exchange function can be stopped by stopping the rotation as needed. The total heat exchanger 10 is rotatably
30 provided with a rotor 12 inside a casing 11, for example. The casing 11 is in the form of

a hollow rectangular parallelepiped and has openings respectively defined in two surfaces opposite to each other in an extending direction of the rotating shaft of the rotor 12. The two openings are respectively partitioned into two of a first region 11B and a second region 11C by a separator 11A, for example. The first region 11B is arranged in the exhaust flow passage 50, and the second region 11C is arranged in the air supply flow passage 40.

[0019] The rotor 12 has, for example, a disk shape and is rotatably supported by the casing 11 so that a disk surface and each opening become parallel with the central axis of the disk as a rotating axis. The rotor 12 has a heat exchange element having a honeycomb structure or a corrugated structure or the like having permeability in the direction of the rotating axis. Further, the rotor 12 is configured to be driven by an unillustrated drive unit in accordance with a drive signal instructed from the control unit 80 and to be rotated with a predetermined rotational speed.

[0020] The air-conditioning core unit 20 is formed with, for example, wet channels 21 for causing a vaporization phenomenon and dry channels 22 passing air to be cooled, through a partition member 23 impermeable to water. The partition member 23 has, for example, first bases 23A and second bases 23B different in shape and is configured such that the wet channels 21 and the dry channels 22 are arranged alternately by alternately disposing the first bases 23A and the second bases 23B.

[0021] The air-conditioning core unit 20 has, for example, a dry inlet 22A of each dry channel 22 on one of sides opposed in the extending direction of the first base 23A and the second base 23B, and has a dry outlet 22B of each dry channel 22 on the other side. Further, the air-conditioning core unit 20 has, for example, a wet inlet 21A and a wet outlet 21B of each wet channel 21 at an upper or lower part thereof. Incidentally, FIG. 3 shows the case where the wet inlet 21A and the wet outlet 21B are provided at the upper part of the air-conditioning core unit 20. The wet inlet 21A is preferably provided on the side of the dry outlet 22B at the upper or lower part of the air-conditioning core unit 20. The wet outlet 21B is preferably provided on the side of the dry inlet 22A at the upper or lower part of the air-conditioning core unit 20. This is thus because the flow of air in the wet channel 21 and the flow of air in the dry channel 22 can be made opposite to each other in direction, and heat exchange efficiency can be improved. For example, the exhaust flow passage 50

is in communication with the wet channel 21 through the wet inlet 21A and the wet outlet 21B. Further, for example, the air supply flow passage 40 is in communication with the dry channel 22 through the dry inlet 22A and the dry outlet 22B.

[0022] The first base 23A shown in FIG. 3 is for forming the wet channel 21, for example.

5 The first base 23A is preferably constituted of, for example, plastic such as polyester or polypropylene impervious to water. A shielding wall 23C which controls the flow of air is provided in a peripheral edge portion of the first base 23A on the wet channel 21 side. Spacers 23D are preferably formed in the first base 23A so as to protrude to the wet channel 21 side by embossing. This is to secure the width of the wet channel 21. In the first base

10 23A, a large number of recesses (dimples) (not shown) are preferably formed between the spacers 23D by emboss processing. This is to suppress an air turbulent flow. A wetting layer (not shown) for holding water is provided in the surface of the first base 23A on the wet channel 21 side. The wetting layer (not shown) is preferably constituted of, for example, a woven fabric or a nonwoven fabric consisting of cellulose or polypropylene or the like. Further, a water absorbent such as titanium oxide or silica gel or the like is
15 preferably applied to the wetting layer. This is because the adsorptivity of water is improved. The wetting layer (not shown) is bonded to each first base 23A by adhesive bonding or thermal compression bonding, for example to constitute the partition member 23.

20 [0023] The second base 23B shown in FIG. 4 is for forming the dry channel 22, for example. As with the first base 23A, the second base 23B is preferably constituted of, for example, plastic such as polyester or polypropylene impervious to water. A shielding wall 23C which controls the flow of air is provided in each of upper and lower edge portions of the second base 23B on the dry channel 22 side. For example, spacers 23D are preferably
25 formed in the second base 23B so as to protrude to the dry channel 22 side by embossing as with the first base 23A. Also, in the second base 23B, a large number of recesses (dimples) (not shown) are preferably formed between the spacers 23D by emboss processing as with the first base 23A. For example, a wetting layer (not shown) for holding water is provided in the surface of the second base 23B on the wet channel 21 side.

30 [0024] The wetting layer is configured to be supplied with water as needed in accordance

with a drive signal instructed from the control unit 80, for example. As a mechanism of supplying water, for example, a water supply pipe may be provided, or water may be sprinkled from above. Further, a water tank is provided on the lower side, and the lower sides of the first base 23A and the second base 23B may be immersed in the water tank.

5 [0025] The heat pump 30 is for transferring heat from a low temperature portion to a high temperature portion by using a heating medium, for example. The heat pump 30 has an expansion valve 31, an evaporator 32, a compressor 33, and a condenser 34 and is configured to circulate the heating medium in turn. The expansion valve 31 is for decompressing the heating medium, for example, and the evaporator 32 is for lowering the
10 temperature by the decompressed heating medium to absorb heat from surrounding air, for example. The compressor 33 is for compressing the heating medium, for example, and the condenser 34 is for increasing the temperature by the compressed heating medium to cause the surrounding air to generate heat, for example.

[0026] The evaporator 32 or the condenser 34 in the heat pump 30 is preferably arranged
15 on the downstream side having passed through the dry channel 22 of the air-conditioning core unit 20 in the air supply flow passage 40. This is to cool or heat the outdoor air having passed through the dry channel 22 and supply the same indoors. Incidentally, it is preferable for the heat pump 30 to make it possible to reverse the functions of the evaporator 32 and the condenser 34 by reversing the flow of the heating medium using a switching
20 valve as a four-way valve, for example. For example, it is preferable that by making reverse the flow of the heating medium in accordance with the drive signal instructed from the control unit 80, the evaporator 32 is arranged on the downstream side of the dry channel 22 in the air supply flow passage 40 during cooling as shown in FIG. 1, and the condenser 34 is arranged on the downstream side of the dry channel 22 in the air supply flow passage
25 40 during heating as shown in FIG. 5.

[0027] The air supply flow passage 40 is formed to, for example, guide the outdoor air to the total heat exchanger 10, allow the same to pass through the second region 11C of the total heat exchanger 10, thereafter guide the same to the dry channel 22 of the air-conditioning core unit 20, and allow the same to pass through the dry channel 22 so as to
30 be supplied indoors. The evaporator 32 or the condenser 34 of the heat pump 30 is

arranged on the downstream side of the dry channel 22.

[0028] The exhaust flow passage 50 has, for example, a first exhaust flow passage 51 which is capable of guiding the indoor air to the total heat exchanger 10, allowing the same to pass through the first region 11B of the total heat exchanger 10, thereafter guiding at least part of the indoor air having passed through the total heat exchanger 10 to the wet channel 21 of the air-conditioning core unit 20, and allowing it to pass through the wet channel 21 to exhaust the same outdoors, and a second exhaust flow passage 52 which is capable of exhausting at least the part of the indoor air having passed through the total heat exchanger 10 outdoors without guiding it to the wet channel 21 of the air-conditioning core unit 20. This is to make it possible to guide the indoor air having passed through the total heat exchanger 10 to the wet channel 21 of the air-conditioning core unit 20.

[0029] The exhaust flow passage 50 is preferably provided with, for example, an indoor air adjusting valve 53 between the total heat exchanger 10 and the air-conditioning core unit 20, which adjusts the flow rate of the indoor air allowed to flow to the air-conditioning core unit 20 after having passed through the total heat exchanger 10, and an exhaust adjusting valve 54 which adjusts the flow rate of the indoor air to be exhausted outdoors without causing the indoor air to flow to the air-conditioning core unit 20 after having passed through the total heat exchanger 10. The indoor air adjusting valve 53 and the exhaust adjusting valve 54 are configured to adjust the flow rate in accordance with the drive signal instructed from the control unit 80, for example. For example, when the indoor air is circulated in the wet channel 21 of the air-conditioning core unit 20 during cooling, the flow rate is preferably adjusted to range from 30 vol.% or more to 50 vol.% or less of the flow rate of the outdoor air circulated in the dry channel 22. This is because it is possible to improve vaporizing efficiency.

[0030] The outdoor air flow passage 60 is capable of, for example, guiding the outdoor air to the wet channel 21 of the air-conditioning core unit 20 and allowing it to pass through the wet channel 21 to exhaust it outdoors. This is to make it possible to guide even the outdoor air to the wet channel 21 of the air-conditioning core unit 20. The indoor air and outdoor air having passed through the total heat exchanger 10 may be both circulated in the wet channel 21 as needed. Incidentally, the outdoor air flow passage 60 may be provided

partly in common with the first exhaust flow passage 51. For example, a part of a portion of guiding the indoor air to the wet channel 21 of the air-conditioning core unit 20 and a portion of exhausting the indoor air outdoors from the wet channel 21 may be made common. Further, the outdoor air flow passage 60 is preferably provided with an outdoor
5 air adjusting valve 61 which allows the outdoor air to flow therein. The outdoor air adjusting valve 61 is configured to adjust the flow rate in accordance with the drive signal instructed from the control unit 80, for example. For example, preferably, the outdoor air adjusting valve 61 is opened as needed during cooling to adjust the outdoor air so that it circulates in the air-conditioning core unit 20.

10 [0031] The air supply fan 71 which supplies the outdoor air may be arranged at any location if it is possible to supply the outdoor air indoors, but is arranged on the upstream side of the total heat exchanger 10, for example. The exhaust fan 72 which exhausts the indoor air may be arranged at any location if it is possible to exhaust the indoor air from indoors, but is arranged on the upstream side of the total heat exchanger 10, for example.

15 The outdoor air circulating fan 73 may be arranged at any location if it is possible to circulate the outdoor air in the wet channel 21 of the air-conditioning core unit 20, but is arranged on the upstream side of the wet channel 21, for example. The air supply fan 71, the exhaust fan 72, and the outdoor air circulating fan 73 are driven according to the drive signal instructed from the control unit 80, for example.

20 [0032] The control unit 80 is configured to control the operations of the total heat exchanger 10, the air-conditioning core unit 20, the heat pump 30, the indoor air adjusting valve 53, the exhaust adjusting valve 54, the outdoor air adjusting valve 61, the air supply fan 71, the exhaust fan 72, and the outdoor air circulating fan 73, for example.

[0033] For example, it is preferable to control the air-conditioning core unit 20 so as to
25 during cooling, supply water to the wetting layer of the wet channel 21 to cool the partition member 23 by the vaporization phenomenon in the wet channel 21 and cool the outdoor air in the dry channel 22 by heat exchange, and further in the case where an indoor temperature is lowered, to control the heat pump 30 so as to adjust the flow of the heating medium and make the evaporator 32 function on the downstream side of the dry channel 22 in the air
30 supply flow passage 40.

[0034] Also, in the case where an outdoor temperature or enthalpy is higher than indoors during cooling, it is preferable to, as shown in FIG. 6 by way of example, control the total heat exchanger 10 so as to rotate the rotor 12 to thereby operate a total heat exchange function, control the exhaust flow passage 50 so as to open the indoor air adjusting valve 53 and the exhaust adjusting valve 54 to guide at least part of the indoor air having passed through the total heat exchanger 10, e.g., a flow rate of 30 vol.% or more and 50 vol.% or less to the wet channel 21 of the air-conditioning core unit 20, and to control the outdoor air flow passage 60 so as to close the outdoor air adjusting valve 61 to prevent the outdoor air from being guided to the wet channel 21. This is because the temperature can be lowered more efficiently by reusing the exhaust of the indoor air lower in temperature than the outdoor air.

[0035] Further, in the case where the indoor temperature or enthalpy is higher than outdoors during cooling, it is preferable to, as shown in FIG. 7 by way of example, control the total heat exchanger 10 so as to stop the rotation of the rotor 12 to deactivate the total heat exchange function, control the exhaust flow passage 50 so as to close the indoor air adjusting valve 53 and open the exhaust adjusting valve 54 to exhaust the indoor air having passed through the total heat exchanger 10 outdoors without being guided to the wet channel 21 of the air-conditioning core unit 20, and control the outdoor air flow passage 60 so as to open the outdoor air adjusting valve 61 to guide the outdoor air to the wet channel 21 of the air-conditioning core unit 20. This is because the temperature can be lowered more efficiently through the use of the cold outdoor air. Incidentally, sensors (not shown) each of which detects the temperature or enthalpy of the indoor air and the temperature or enthalpy of the outdoor air before passing through the total heat exchanger 10 are preferably provided at appropriate locations of the air supply flow passage 40 and the exhaust flow passage 50.

[0036] It is preferable to, as shown in FIG. 5 by way of example, during heating, control the total heat exchanger 10 so as to rotate the rotor 12 to operate the total heat exchange function, control the exhaust flow passage 50 so as close the indoor air adjusting valve 53 and open the exhaust adjusting valve 54 to exhaust the indoor air having passed through the total heat exchanger 10 outdoors without being guided to the wet channel 21 of the air-

conditioning core unit 20, control the outdoor air flow passage 60 so as to close the outdoor air adjusting valve 61 to prevent the outdoor air from being guided to the wet channel 21, and control the air-conditioning core unit 20 so as to deactivate the air-conditioning core unit 20 without supplying water to the wetting layer of the wet channel 21. Further, in the case where the indoor temperature is raised, it is preferable to control the heat pump 30 so as to adjust the flow of the heating medium and allow the condenser 34 to function on the downstream side of the dry channel 22 in the air supply flow passage 40.

[0037] This air-conditioning system 1 can be used in air conditioning in the following manner, for example. FIG. 8 shows the flow of operations of the air-conditioning system

1. First, for example, switching between cooling and heating is performed by operation mode switching (Step S101).

[0038] During cooling (Step S101: cooling), the indoor and outdoor temperatures or enthalpies are first compared (Step S201). When the outdoor temperature or enthalpy is higher than indoors (Step S201: outdoors>indoors), as shown in FIG. 6, for example, the total heat exchange function of the total heat exchanger 10 is operated to perform heat exchange between the indoor air and the outdoor air (Step S211). The indoor air adjusting valve 53 and the exhaust adjusting valve 54 are opened and the outdoor air adjusting valve 61 is closed to circulate at least part of the indoor air having passed through the total heat exchanger 10, e.g., the flow rate of 30 vol.% or more and 50 vol.% or less in the wet channel 21 of the air-conditioning core unit 20, and the remainder of the indoor air having passed through the total heat exchanger 10 is exhausted outdoors (Step S212). Further, water is supplied to the wetting layer of the wet channel 21 to cool the partition member 23 by the vaporization phenomenon in the wet channel 21 (Step S213) and cool the outdoor air passing through the total heat exchanger 10 and guided to the dry channel 22 by heat exchange, and then the outdoor air is supplied indoors and the air having passed through the wet channel 21 is exhausted outdoors.

[0039] Thus, the outdoor air is cooled by heat exchange with the cold indoor air in the total heat exchanger 10 and thereafter subjected to indirect vaporization cooling in the air-conditioning core unit 20 and supplied indoors. At this time, since the exhaust of the indoor air lower in temperature than the outdoor air is reused in the indirect vaporization

cooling, the temperature can be lowered more efficiently. Also, when it is desired to further lower the temperature of the outdoor air having passed through the air-conditioning core unit 20, the heat pump 30 is operated to cool it.

[0040] Further, during cooling (Step S101: cooling), when the indoor temperature or enthalpy is higher than outdoors (Step S201: outdoors<indoors), as shown in FIG. 7, for example, the total heat exchange function of the total heat exchanger 10 is deactivated to stop the heat exchange between the indoor air and the outdoor air (Step S221). The indoor air adjusting valve 53 is closed and the exhaust adjusting valve 54 and the outdoor air adjusting valve 61 are opened to exhaust the indoor air having passed through the total heat exchanger 10 outdoors without being guided to the wet channel 21 of the air-conditioning core unit 20 and circulate the outdoor air in the wet channel 21 (Step S222). Further, water is supplied to the wetting layer of the wet channel 21 to cool the partition member 23 by the vaporization phenomenon in the wet channel 21 (Step S223) and cool the outdoor air passing through the total heat exchanger 10 and guided to the dry channel 22 by heat exchange, and then the outdoor air is supplied indoors and the air having passed through the wet channel 21 is exhausted outdoors.

[0041] Thus, the outdoor air is not heat-exchanged in the total heat exchanger 10 and is subjected to the indirect vaporization cooling in the air-conditioning core unit 20 and supplied indoors. At this time, since the cold outdoor air is used in the indirect vaporization cooling, the temperature can be lowered more efficiently. Also, when it is desired to further lower the temperature of the outdoor air having passed through the air-conditioning core unit 20, the heat pump 30 is operated to cool it.

[0042] Further, during heating (Step S101: heating), as shown in FIG. 5, for example, the total heat exchange function of the total heat exchanger 10 is operated to perform heat exchange between the indoor air and the outdoor air (Step S301). The indoor air adjusting valve 53 is closed, the exhaust adjusting valve 54 is opened, and the outdoor air adjusting valve 61 is closed to exhaust the indoor air having passed through the total heat exchanger 10 outdoors without being guided to the wet channel 21 of the air-conditioning core unit 20 and stop guiding of the outdoor air to the wet channel 21 even from the outdoor air flow passage 60 (Step S302). The air-conditioning core unit 20 is deactivated in function

without supplying water to the wetting layer of the wet channel 21 (Step S303). The outdoor air having passed through the total heat exchanger 10 is allowed to pass through the dry channel 22 of the air-conditioning core unit 20 and supplied indoors. Consequently, after the outdoor air is heated by heat exchange with the warm indoor air in the total heat exchanger 10, the outdoor air passes through the air-conditioning core unit 20 and is supplied indoors. Further, when it is desired to further raise the temperature of the outdoor air having passed through the air-conditioning core unit 20, the heat pump 30 is operated to heat it.

[0043] FIG. 9 shows a result of simulation where cooling is performed using the air-conditioning system 1 shown in FIG. 6 (where the outdoor temperature or enthalpy is higher than indoors). In FIG. 9, in the case where the temperature of the outdoor air is assumed to be 35°C and specific humidity thereof is assumed to be 16.5g/kg, the room temperature of the indoor air is assumed to be 28°C and specific humidity thereof is assumed to be 12.0g/kg, and the temperature of the outdoor air when it is supplied indoors is assumed to be 16°C and specific humidity thereof is assumed to be 10.8g/kg, the supply air flow rate of the outdoor air is taken to be 18000m³/h, and the exhaust flow rate (exhaust flow rate of indoor air passing through the total heat exchanger 10) of the indoor air is taken to be 18000m³/h, and the total heat exchanger 10 is operated to circulate half of the indoor air having passed through the total heat exchanger 10 in the wet channel 21 of the air-conditioning core unit 20 and supply water to the wetting layer of the wet channel 21 to thereby allow the evaporator 32 to function on the downstream side of the dry channel 22.

[0044] As a result, it can be seen that the temperature of the outdoor air after having passed through the total heat exchanger 10 becomes 30°C, the specific humidity thereof becomes 13.6g/kg, and the temperature of the outdoor air after having passed through the dry channel 22 of the air-conditioning core unit 20 becomes 25.2°C and the specific humidity thereof becomes 13.6g/kg, and that the temperature of the air cooled by the heat pump 30 and the specific humidity thereof can respectively be lowered from 35°C and 16.5g/kg to 25.2°C and 13.6g/kg. At this time, the amount of heat required in the total heat exchanger 10 and the air-conditioning core unit 20 is 103.2kW, and power consumption is 9.0kW. Further, the amount of heat necessary to lower the outdoor air

having the temperature 25.2°C and the specific humidity 13.6g/kg having passed through the dry channel 22 to the temperature 16°C and the specific humidity 10.8g/kg by the heat pump 30 is 98.2kW and power consumption is 22.1kW. That is, the total amount of heat required for this air-conditioning system 1 is 201.4kW, and the total power consumption thereof is 31.1kW.

[0045] On the other hand, assuming that the supply air flow rate of the outdoor air is 18000m³/h similarly when the same outdoor air (temperature: 35°C and specific humidity: 16.5g/kg) is cooled to the temperature 16°C and the specific humidity 10.8g/kg only by the heat pump, the required amount of heat is 201.4kW and power consumption is 55.0kW.

Thus, according to this air-conditioning system 1, it can be seen that the amount of heat in the heat pump 30 can be reduced by 51.2%, and the power consumption of the whole system can be reduced by 43%.

[0046] Further, FIG. 10 shows a result of simulation where cooling is performed using the air-conditioning system 1 shown in FIG. 7 (where the indoor temperature or enthalpy is higher than outdoors). In FIG. 10, in the case where the temperature of the outdoor air is assumed to be 25.0°C and specific humidity thereof is assumed to be 12.3g/kg, the room temperature of the indoor air is assumed to be 28.0°C and specific humidity thereof is assumed to be 12.0g/kg, and the temperature of the outdoor air when it is supplied indoors is assumed to be 16.0°C and specific humidity thereof is assumed to be 10.8g/kg, the supply air flow rate of the outdoor air is taken to be 18000m³/h, and the exhaust flow rate (exhaust flow rate of indoor air passing through the total heat exchanger 10) of the indoor air is taken to be 18000m³/h, and the total heat exchanger 10 is stopped to circulate outdoor air of 9000m³/h in the wet channel 21 of the air-conditioning core unit 20 and supply water to the wetting layer of the wet channel 21 to thereby allow the evaporator 32 to function on the downstream side of the dry channel 22.

[0047] As a result, it can be seen that the temperature of the outdoor air after having passed through the total heat exchanger 10 becomes 25.0°C, and the specific humidity thereof becomes 12.3g/kg, and the temperature of the outdoor air after having passed through the dry channel 22 of the air-conditioning core unit 20 becomes 21.2°C and the specific humidity thereof becomes 12.3g/kg, and that the temperature of the air cooled by

the heat pump 30 can be lowered from 25°C to 21.2°C. At this time, the amount of heat required in the total heat exchanger 10 and the air-conditioning core unit 20 is 23.1kW, and power consumption is 0.5kW. Further, the amount of heat necessary to lower the outdoor air having the temperature 21.2°C and the specific humidity 12.3g/kg having passed through the dry channel 22 to the temperature 16°C and the specific humidity 10.8g/kg by the heat pump 30 is 54.2kW and power consumption is 17.7kW. That is, the total amount of heat required for this air-conditioning system 1 is 77.3kW, and the total power consumption thereof is 18.2kW.

[0048] On the other hand, assuming that the supply air flow rate of the outdoor air is 18000m³/h similarly when the same outdoor air (temperature: 25°C and specific humidity: 12.3g/kg) is cooled to the temperature 16°C and the specific humidity 10.8g/kg only by the heat pump, the required amount of heat is 77.4kW and power consumption is 29.0kW. Thus, according to this air-conditioning system 1, it can be seen that the amount of heat in the heat pump 30 can be reduced by 30.0%, and the power consumption of the whole system can be reduced by 37.2%.

[0049] Further, FIG. 11 shows a result of simulation where heating is performed using the air-conditioning system 1 shown in FIG. 5. In FIG. 11, in the case where the temperature of the outdoor air is assumed to be -3.4°C and specific humidity thereof is assumed to be 2.0g/kg, the room temperature of the indoor air is assumed to be 22°C and specific humidity thereof is assumed to be 7.4g/kg, and the temperature of the outdoor air when it is supplied indoors is assumed to be 23°C and specific humidity thereof is assumed to be 5.5g/kg, the supply air flow rate of the outdoor air is taken to be 18000m³/h, and the exhaust flow rate (exhaust flow rate of indoor air passing through the total heat exchanger 10) of the indoor air is taken to be 18000m³/h, and the total heat exchanger 10 is operated to exhaust all of the indoor air having passed through the total heat exchanger 10 outdoors without being guided to the wet channel 21, stop guiding of the outdoor air to the wet channel 21 even from the outdoor air flow passage 60, deactivate the air-conditioning core unit 20 without supplying water to the wetting layer of the wet channel 21, and allow the condenser 34 to function on the downstream side of the dry channel 22.

[0050] As a result, it can be seen that the temperature of the outdoor air after having

passed through the total heat exchanger 10 becomes 13.1°C, the specific humidity thereof becomes 5.5g/kg, and the temperature of the outdoor air after having passed through the dry channel 22 of the air-conditioning core unit 20 becomes 13.1°C and the specific humidity thereof becomes 5.5g/kg, and that the temperature of the air heated by the heat pump 30 can be increased from -3.4°C to 13.1°C. At this time, the amount of heat required in the total heat exchanger 10 is 100.2kW, and power consumption is 9.0kW. Further, the amount of heat necessary to raise the outdoor air having the temperature 13.1°C and the specific humidity 5.5g/kg having passed through the dry channel 22 to the temperature 23.0°C and the specific humidity 5.5g/kg by the heat pump 30 is 60.1kW and power consumption is 18.3kW. That is, the total amount of heat required for this air-conditioning system 1 is 160.3kW, and the total power consumption thereof is 27.3kW.

[0051] On the other hand, assuming that the supply air flow rate of the outdoor air is 18000m³/h similarly where the same outdoor air (temperature: -3.4°C and specific humidity: 2.0g/kg) is heated to the temperature 23.0°C and the specific humidity 5.5g/kg only by the heat pump, the required amount of heat is 213.0kW and power consumption is 54.6kW. Thus, according to this air-conditioning system 1, it can be seen that the amount of heat in the heat pump 30 can be reduced by 71.8%, and the power consumption of the whole system can be reduced by 50.0%.

[0052] Thus, according to the present embodiment, the total heat exchanger 10 and the air-conditioning core unit 20 are combined to enable the outdoor air heat-exchanged by the total heat exchanger 10 to pass through the dry channel 22 of the air-conditioning core unit 20. Therefore, for example, in summertime during which the outdoor temperature or enthalpy is higher than indoors, the total heat exchanger 10 performs heat exchange between the hot outdoor air and the cold indoor air to lower the temperature of the outdoor air, and thereafter the air-conditioning core unit 20 is capable of supplying water to the wetting layer of the wet channel 21 to cool the outdoor air in the dry channel 22 by the vaporization phenomenon in the wet channel 21. Further, since it is possible to circulate at least part of the indoor air having passed through the total heat exchanger 10 in the wet channel 21 of the air-conditioning core unit 20, the temperature can be lowered by reusing the exhaust lower in temperature than the outdoor air. It is thus possible to efficiently cool

the outdoor air.

[0053] Also, for example, in an intermediate period during which the indoor temperature or enthalpy is higher than outdoors, the temperature can be lowered by using the cold outdoor air if the total heat exchanger 10 is stopped to guide the outdoor air to the wet channel 21. Thus, even in the case where at night in summer, or in spring and autumn or the like, the indoor temperature becomes higher than the outdoor temperature, and it is desired to lower the indoor temperature, it can be cooled efficiently.

[0054] Further, if the evaporator 32 or the condenser 34 in the heat pump 30 is arranged on the downstream side of the dry channel 22 in the air supply flow passage 40, the outdoor air cooled by the air-conditioning core unit 20 can be further cooled by the evaporator 32. In addition, the outdoor air heat-exchanged by the total heat exchanger 10 can be further heated by the condenser 34. It is thus possible to efficiently perform cooling and heating as compared with the case where the cooling and heating are performed only by the heat pump 30.

[0055] (Second embodiment)

FIGS. 12 and 13 respectively illustrate a schematic configuration of an air-conditioning system 1 according to a second embodiment of the present invention. FIG. 12 is indicative of during cooling, and FIG. 13 is indicative of during heating. This air-conditioning system 1 has the same configuration and operation/effects as those in the first embodiment in other respects except that the position of arrangement of an evaporator 232 or a condenser 234 in a heat pump 230 is different from that in the first embodiment. Therefore, the same components are denoted by the same reference numerals, and reference numerals with “2” added to the hundredth place are assigned to the corresponding components, and a detailed description about the same parts will therefore be omitted.

[0056] In the heat pump 230, during cooling, as shown in FIG. 12, the evaporator 232 is arranged on the downstream side having passed through the dry channel 22 of the air-conditioning core unit 20 in the air supply flow passage 40, and the condenser 234 is arranged on the downstream side having passed through the total heat exchanger 10 in the exhaust flow passage 50. Further, during heating, as shown in FIG. 13, the condenser 234 is arranged on the downstream side having passed through the dry channel 22 of the air-

conditioning core unit 20 in the air supply flow passage 40, and the evaporator 232 is arranged on the downstream side having passed through the total heat exchanger 10 in the exhaust flow passage 50.

[0057] Thus, since the heat of the condenser 234 is deprived by using the exhaust having passed through the total heat exchanger 10, which is lower in temperature than the outdoor air during cooling, it is possible to improve the efficiency of the heat pump 30 and achieve energy saving as compared with the case where the outdoor air is used. Further, since the evaporator 232 is heated by using the exhaust having passed through the total heat exchanger 10, which is higher in temperature than the outdoor air during heating, it is possible to improve the efficiency of the heat pump 30 and achieve energy saving as compared with the case where the outdoor air is used.

[0058] Although the present invention has been described above by taking the embodiments, the present invention is not limited to the above-mentioned embodiments and can be modified in various ways. For example, although the above-mentioned embodiments have been specifically described about the configuration of the air-conditioning core unit 20, each of them may have another configuration. For example, although the above-mentioned embodiment has described where the first base 23A and the second base 23B are alternately disposed to thereby alternately arrange the wet channel 21 and the dry channel 22 through the partition member 23, a wet channel and a dry channel may be formed by a partition member having another configuration.

[0059] Also, although the above-mentioned embodiment has described where in the air-conditioning core unit 20, the flow of the air in the wet channel 21 and the flow of the air in the dry channel 22 are made opposite to each other in direction, the flow of the air in the wet channel 21 and the flow of the air in the dry channel 22 may be made orthogonal.

[0060] Further, the heat pumps 30 and 230 may be provided such that the expansion valve 31, the evaporators 32 and 232, the compressor 33, and the condensers 34 and 234 are respectively configured integrally. Furthermore, the heat pump may be constituted as a structure in which the expansion valve 31 and the compressor 33 are disposed in separated places and connected to each other with piping.

[0061] In addition, although the above-mentioned embodiment has described where the

air-conditioning core unit 20 is made not to function without during heating, circulating the air in the wet channel 21 of the air-conditioning core unit 20 and supplying water to the wetting layer of the wet channel 21, humidification may be performed by, for example, performing piping so that the indoor air can be circulated in the wet channel 21 of the air-conditioning core unit 20 and thereafter returned indoors, and during heating, circulating the indoor air in the wet channel 21 and supplying water to the wetting layer of the wet channel 21.

[0062] Moreover, although the above-mentioned embodiment has specifically described the respective components, it is not necessary to provide all the components, and other components may be provided.

Industrial Applicability

[0063] The invention can be used in air-conditioning.

Description of Reference Numerals

[0064] 1 ... air-conditioning system, 10 ... total heat exchanger, 11 ... casing, 11A ... separator, 11B ... first region, 11C ... second region, 12 ... rotor, 20 ... air-conditioning core unit, 21 ... wet channel, 21A ... wet inlet, 21B ... wet outlet, 22 ... dry channel, 22A ... dry inlet, 22B ... dry outlet, 23 ... partition member, 23A ... first base, 23B ... second base, 23C ... shielding wall, 23D ... spacer, 30 ... heat pump, 31 ... expansion valve, 32 ... evaporator, 33 ... compressor, 34 ... condenser, 40... air supply flow passage, 50 ... exhaust flow passage, 51 ... first exhaust flow passage, 52 ... second exhaust flow passage, 53 ... indoor air adjusting valve, 54 ... exhaust adjusting valve, 60 ... outdoor air flow passage, 61 ... outdoor air adjusting valve, 71 ... air supply fan, 72 ... exhaust fan, 73 ... outdoor air circulating fan, 80 ... control unit.

CLAIMS

1. An air-conditioning system comprising:

5 a total heat exchanger which exchanges heat between indoor air and outdoor air;

an air-conditioning core unit having a wet channel which causes a vaporization phenomenon, and a dry channel passing air to be cooled both being formed through a water-impermeable partition member provided with a wetting layer holding water on a side of the wet channel;

10 an air supply flow passage which guides the outdoor air to the dry channel of the air-conditioning core unit after guiding the outdoor air to the total heat exchanger to supply the outdoor air to indoors;

15 an exhaust flow passage having a first exhaust flow passage capable of after guiding the indoor air to the total heat exchanger, guiding at least part of the indoor air having passed through the total heat exchanger to the wet channel of the air-conditioning core unit to exhaust the indoor air to outdoors, and a second exhaust flow passage capable of exhausting at least the part of the indoor air having passed through the total heat exchanger to outdoors without being guided to the wet channel of the air-conditioning core unit;

20 an outdoor air flow passage capable of guiding the outdoor air to the wet channel of the air-conditioning core unit to exhaust the outdoor air to outdoors;

an air supply fan which supplies the outdoor air through the air supply flow passage;

an exhaust fan which exhausts the indoor air through the exhaust flow passage;

25 an outdoor air circulating fan which causes the wet channel to circulate the outdoor air through the outdoor air flow passage; and

a control unit which controls their operations,

30 wherein in a case where an outdoor temperature or enthalpy is higher than indoors during cooling, the control unit controls the total heat exchanger to operate a total heat exchange function, controls the exhaust flow passage to guide at least the part of the

indoor air having passed through the total heat exchanger to the wet channel of the air-conditioning core unit, and controls the air-conditioning core unit to supply water to the wetting layer of the wet channel to cool the partition member by the vaporization phenomenon in the wet channel and cool the outdoor air in the dry channel by the heat exchange, and in a case where an indoor temperature or enthalpy is higher than outdoors, the control unit controls the total heat exchanger to stop the total heat exchange function, controls the exhaust flow passage to exhaust the indoor air having passed through the total heat exchanger outdoors without being guided to the wet channel of the air-conditioning core unit, controls the outdoor air flow passage to guide the outdoor air to the wet channel, and controls the air-conditioning core unit to supply water to the wetting layer of the wet channel to cool the partition member by the vaporization phenomenon in the wet channel and cool the outdoor air in the dry channel by the heat exchange.

2. The air-conditioning system according to claim 1, comprising:

a heat pump having an evaporator which decompresses a heating medium to thereby lower temperature to absorb heat, and a condenser which pressurizes the heating medium to thereby raise the temperature to generate heat,

wherein the evaporator or the condenser is arranged on a downstream side having passed through the dry channel of the air-conditioning core unit in the air supply flow passage.

3. The air-conditioning system according to claim 2, wherein in the heat pump, the evaporator is arranged on the downstream side having passed through the dry channel of the air-conditioning core unit in the air supply flow passage, and the condenser is arranged on a downstream side having passed through the total heat exchanger in the exhaust flow passage, or the condenser is arranged on the downstream side having passed through the dry channel of the air-conditioning core unit in the air supply flow passage, and the evaporator is arranged on the downstream side having passed through the total heat exchanger in the exhaust flow passage.

4. The air-conditioning system according to claim 1, wherein during heating, the control unit controls the total heat exchanger to operate the total heat exchange function, controls the exhaust flow passage to exhaust the indoor air having passed through the total heat exchanger to outdoors without being guided to the wet channel of the air-conditioning core unit, controls the outdoor air flow passage not to guide the outdoor air to the wet channel, and controls the air-conditioning core unit to stop in function without supplying water to the wetting layer of the wet channel.

5. An air-conditioning method comprising steps of, using the air-conditioning system according to claim 1:

in a case where an outdoor temperature or enthalpy is higher than indoors during cooling, operating the total heat exchange function of the total heat exchanger to perform heat exchange between the indoor air and the outdoor air, allowing at least part of the indoor air having passed through the total heat exchanger to be circulated in the wet channel of the air-conditioning core unit, supplying water to the wetting layer of the wet channel to cool the partition member by the vaporization phenomenon in the wet channel, and cooling the outdoor air having passed through the total heat exchanger and guided to the dry channel by the heat exchange so as to be supplied indoors; and

in a case where an indoor temperature or enthalpy is higher than outdoors during cooling, stopping the total heat change function of the total heat exchanger, exhausting the indoor air having passed through the total heat exchanger to outdoors without being guided to the wet channel of the air-conditioning core unit, allowing the outdoor air to be circulated in the wet channel, supplying water to the wetting layer of the wet channel to cool the partition member by the vaporization phenomenon in the wet channel, and cooling the outdoor air having passed through the total heat exchanger and guided to the dry channel by the heat exchange so as to be supplied indoors.

6. The air-conditioning method according to claim 5, comprising steps of:
during heating, operating the total heat exchange function of the total heat exchanger to perform heat exchange between the indoor air and the outdoor air,

exhausting the indoor air having passed through the total heat exchanger to outdoors without being guided to the wet channel of the air-conditioning core unit, allowing the outdoor air not to be guided to the wet channel even from the outdoor air flow passage, allowing the air-conditioning core unit to stop in function without supplying water to the wetting layer of the wet channel, and allowing the outdoor air having passed through the total heat exchanger to pass through the dry channel of the air-conditioning core unit so as to be supplied indoors.

7. An air-conditioning method comprising steps of, using the air-conditioning system according to claim 2:

in a case where an outdoor temperature or enthalpy is higher than indoors during cooling, operating the total heat exchange function of the total heat exchanger to perform heat exchange between the indoor air and the outdoor air, allowing at least part of the indoor air having passed through the total heat exchanger to be circulated in the wet channel of the air-conditioning core unit, supplying water to the wetting layer of the wet channel to cool the partition member by the vaporization phenomenon in the wet channel, and cooling the outdoor air having passed through the total heat exchanger and guided to the dry channel by the heat exchange so as to be supplied indoors;

in a case where an indoor temperature or enthalpy is higher than outdoors during cooling, stopping the total heat change function of the total heat exchanger, exhausting the indoor air having passed through the total heat exchanger to outdoors without being guided to the wet channel of the air-conditioning core unit, allowing the outdoor air to be circulated in the wet channel, supplying water to the wetting layer of the wet channel to cool the partition member by the vaporization phenomenon in the wet channel, and cooling the outdoor air having passed through the total heat exchanger and guided to the dry channel by the heat exchange so as to be supplied indoors;

during cooling, cooling the outdoor air having passed through the dry channel by the evaporator of the heat pump so as to be supplied indoors; and

during heating, heating the outdoor air having passed through the dry channel by the condenser of the heat pump so as to be supplied indoors.