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(57) **ABSTRACT**

A heat pump is provided. The heat pump may include an outdoor heat exchanger that performs a heat exchange operation between refrigerant and outdoor air. The outdoor heat exchanger may include a refrigerant tube that guides refrigerant therethrough, and one or more fins coupled to the refrigerant tube. One face of each of the fins may be coated with a water repellent coating material and another face thereof may be coated with a hydrophilic coating material. An area coated with the water repellent coating material may be greater than an area coated with the hydrophilic coating material.

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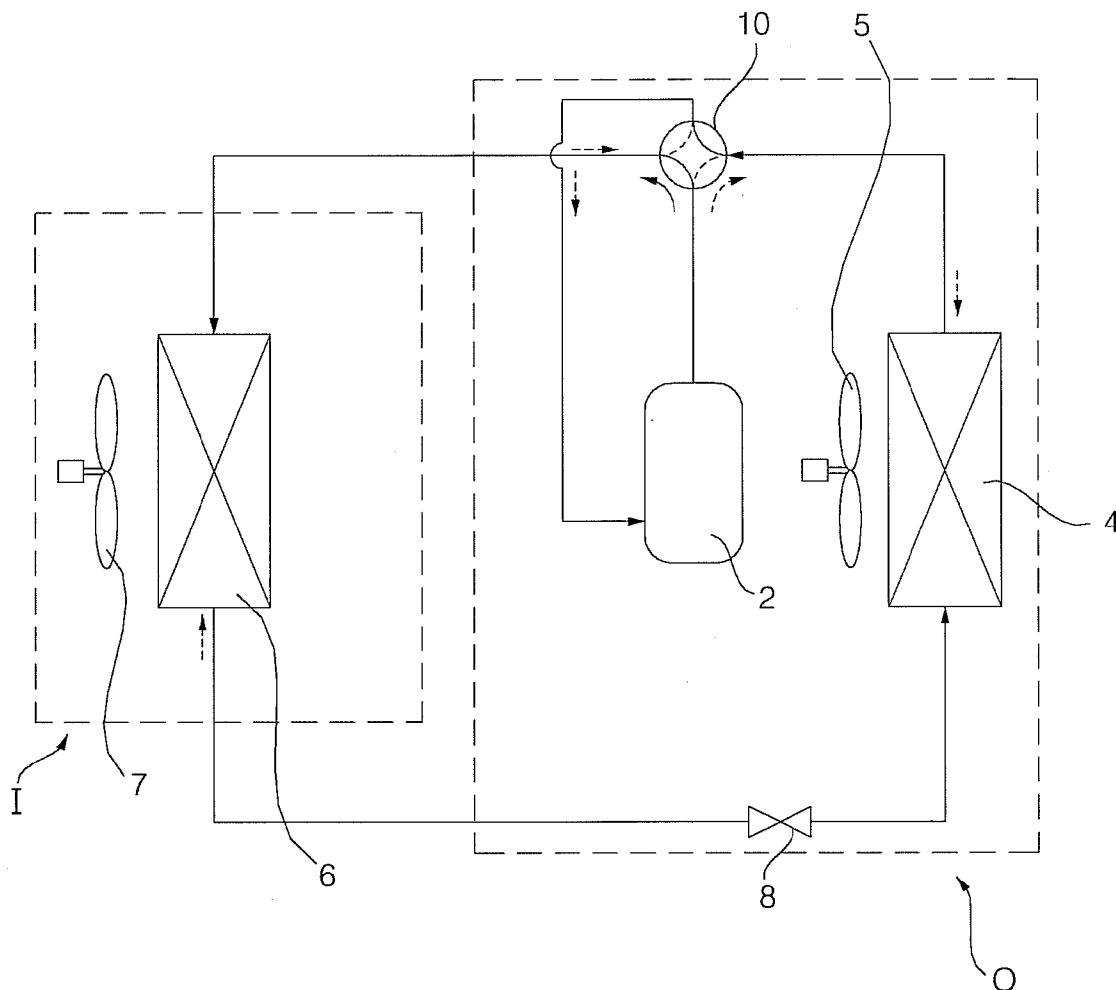


FIG. 1

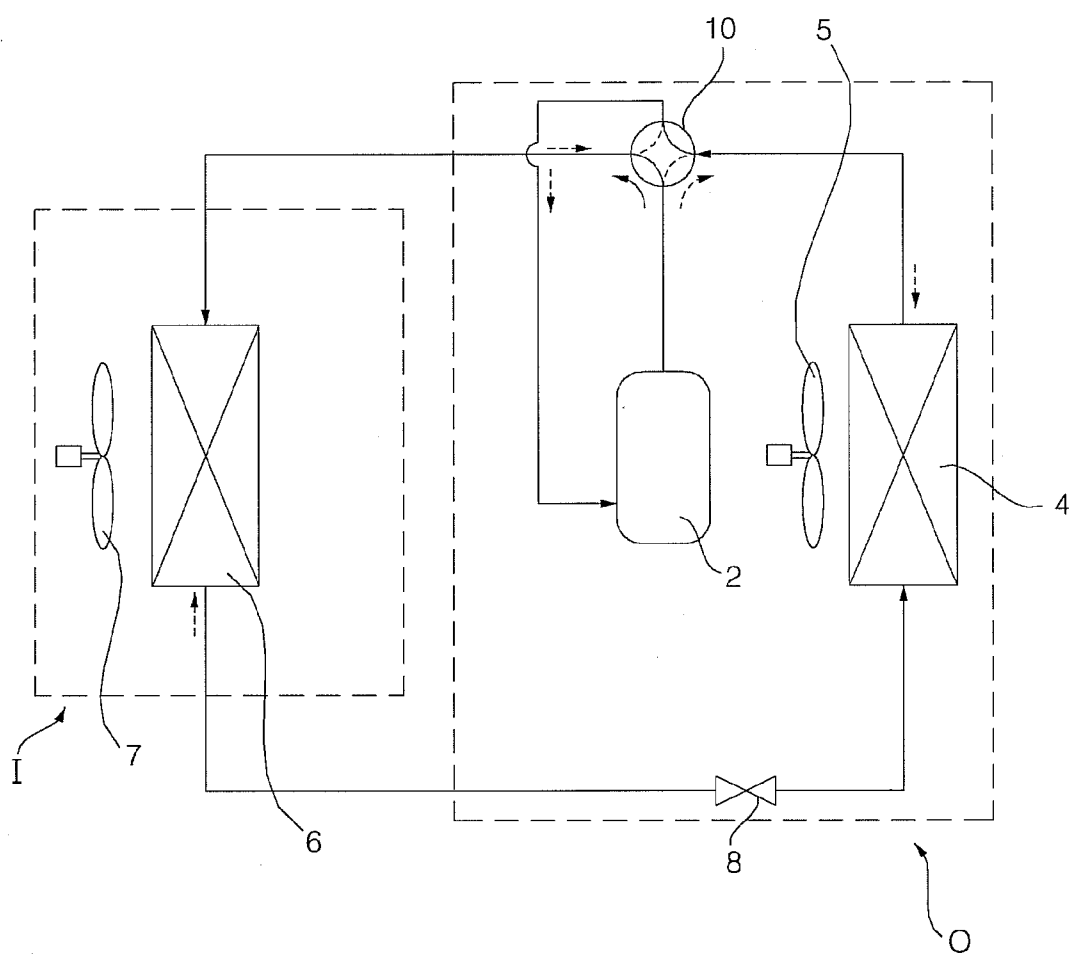


FIG. 2

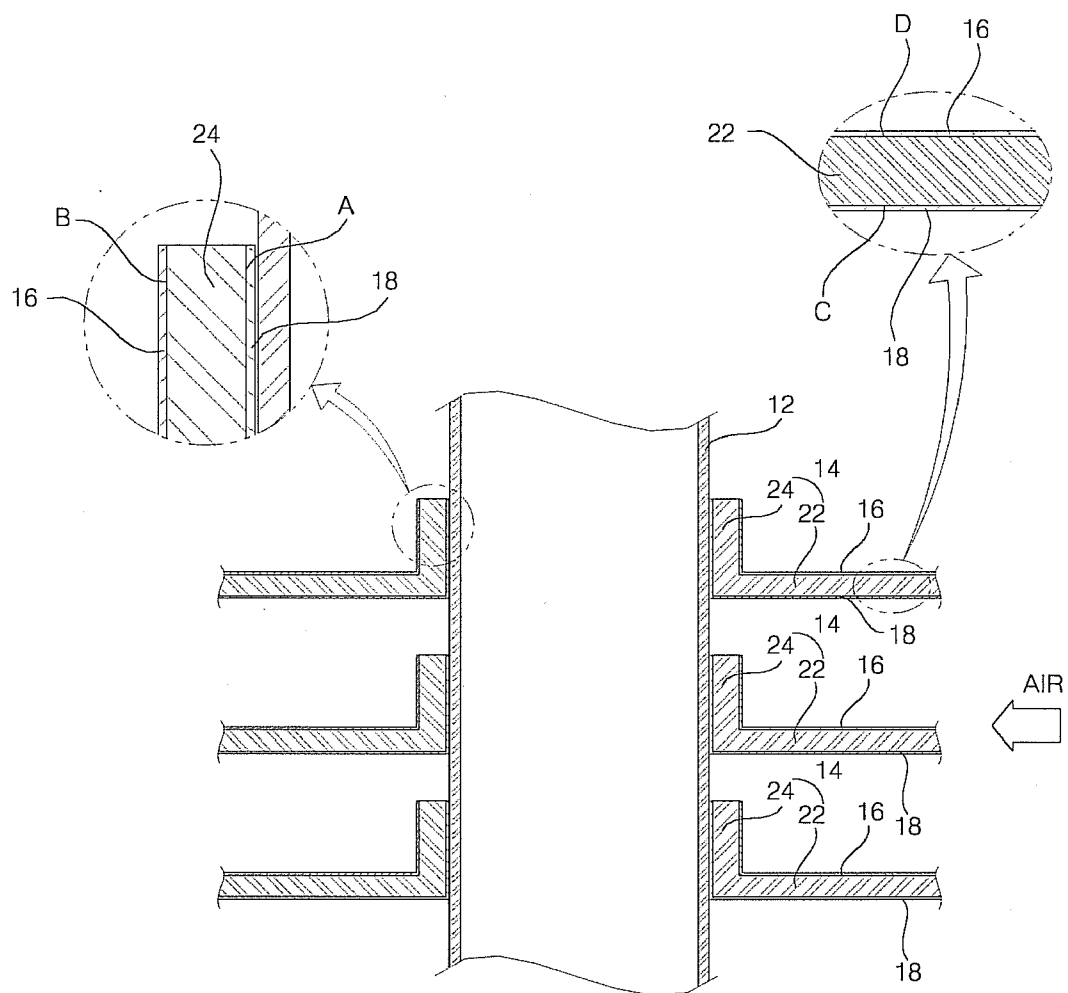


FIG. 3

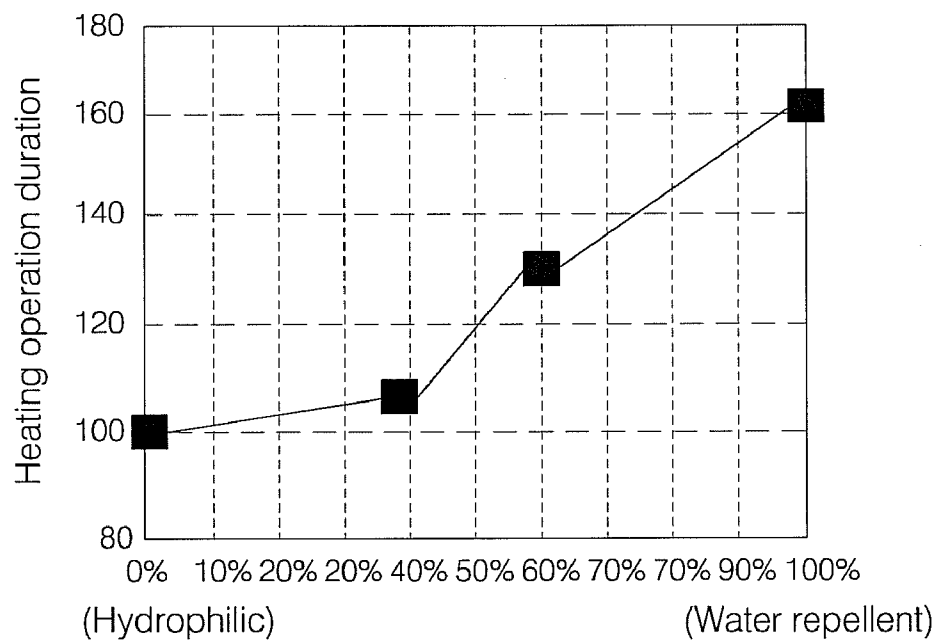


FIG. 4

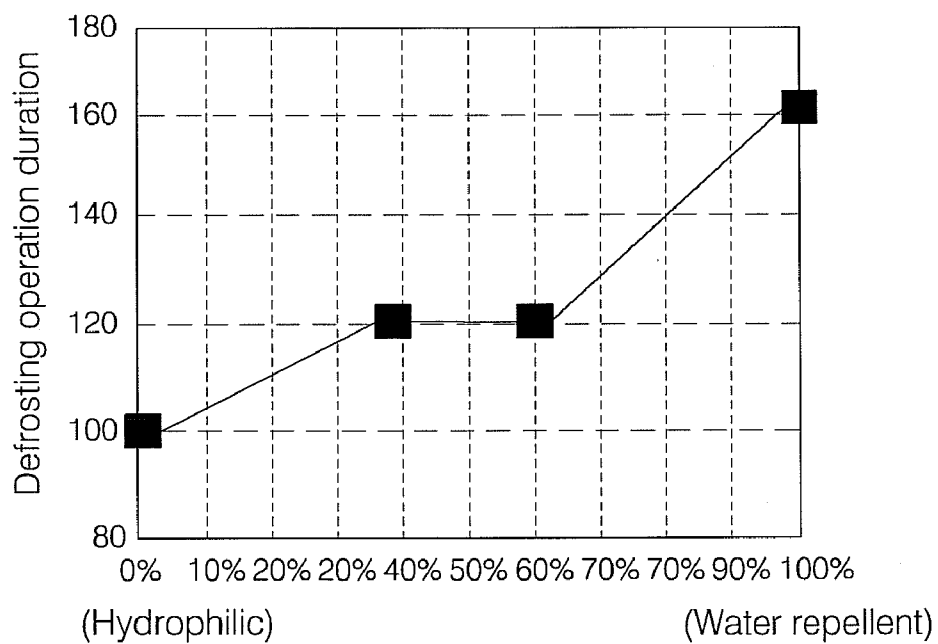


FIG. 5

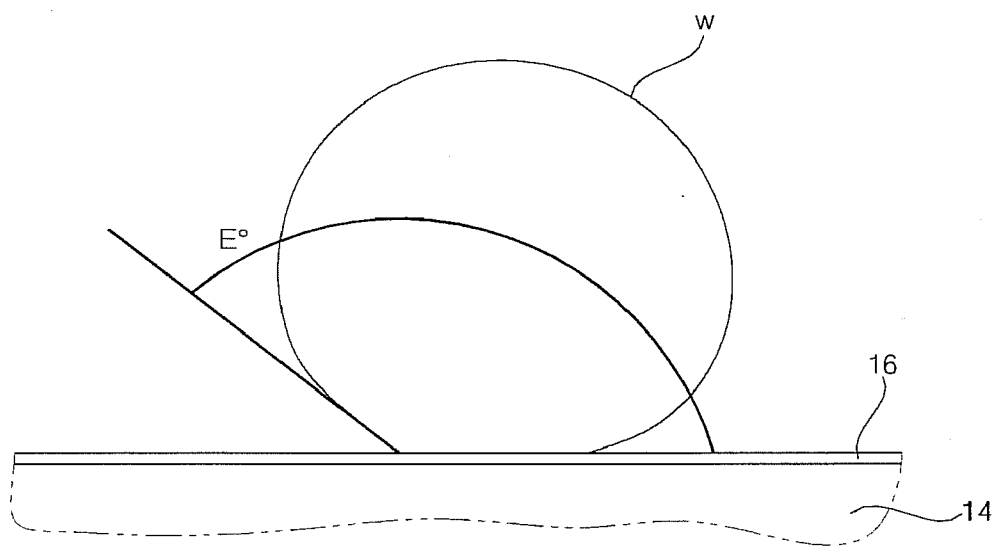
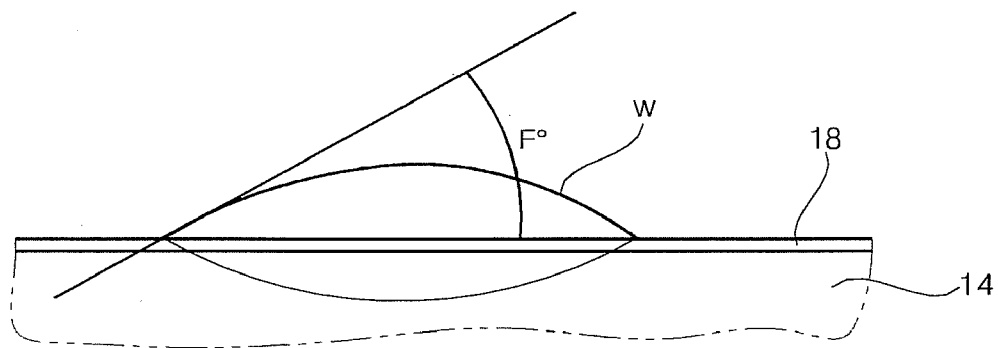


FIG. 6



## OUTDOOR HEAT EXCHANGER AND HEAT PUMP HAVING THE SAME

### CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority under 35 U.S.C. §119 to Korean Application No. 10-2010-0115643 filed on Nov. 19, 2010, whose entire disclosure(s) is/are hereby incorporated by reference.

### BACKGROUND

[0002] 1. Field

[0003] This relates to a heat exchanger and a heat pump having the same and, more particularly, to an outdoor heat exchanger including a hydrophilic coating and a water repellent coating, and a heat pump having the same.

[0004] 2. Background

[0005] In general, a heat pump is a device which includes a compressor, a condensation heat exchanger, an expansion mechanism, and an evaporation heat exchanger. Such a heat pump may be used to cool or heat an indoor area and/or to supply hot water.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The embodiments will be described in detail with reference to the following drawings in which like reference numerals refer to like elements wherein:

[0007] FIG. 1 is a schematic view of a heat pump according to an embodiment as broadly described herein;

[0008] FIG. 2 is an enlarged view of a section of an outdoor heat exchanger of the heat pump shown in FIG. 1;

[0009] FIG. 3 is a graph of a heating operation duration with a respect to a ratio of hydrophilic coating and water repellent coating of the heat pump shown in FIGS. 1 and 2;

[0010] FIG. 4 is a graph of a defrosting operation duration with respect to a ratio of hydrophilic coating and water repellent coating of the heat pump shown in FIGS. 1 and 2;

[0011] FIG. 5 is an enlarged side view of condensation water generated on a water repellent coated fin of the heat pump shown in FIGS. 1 and 2; and

[0012] FIG. 6 is an enlarged side view of condensation water generated on a hydrophilic coated fin of the heat pump shown in FIGS. 1 and 2.

### DETAILED DESCRIPTION

[0013] With reference to FIG. 1, a heat pump as embodied and broadly described herein may include a compressor 2 for compressing a refrigerant, and an outdoor heat exchanger 4 for heat-exchanging a refrigerant with outdoor air. The outdoor heat exchanger 4 allows a refrigerant to be heat-exchanged with outdoor air flowing due to operation of an outdoor fan 5 to thus condense or evaporate the refrigerant.

[0014] The heat pump may include an indoor heat exchanger 6 allowing a refrigerant to be heat-exchanged with indoor air, or heat-exchanged with a heating medium such as an anti-freeze solution, water, or the like.

[0015] The heat pump may be configured as a heat pump type air-conditioner and/or a heat pump type hot water supply device. In the case of the heat pump type air-conditioner, indoor air is heat-exchanged with the refrigerant in the indoor heat exchanger 6 and then discharged into an indoor area to change an indoor temperature. In the case of the heat pump type hot water supply device, a heating medium such as water,

an anti-freeze solution, or the like, may be heat-exchanged with a refrigerant in the indoor heat exchanger 6 so as to be used for supplying hot water.

[0016] In the case of the heat pump type air-conditioner, the indoor heat exchanger 6 includes a refrigerant tube allowing a refrigerant to pass therethrough and a fin-tube heat exchanger including one or more fins coupled with the refrigerant tube, whereby indoor air is in contact with the fin-tube heat exchanger so as to be heat-exchanged with a refrigerant.

[0017] The indoor heat-exchanger 6 heat-exchanges indoor air flowing due to operation of an indoor fan 7 with a refrigerant that passes through therein to condense or evaporate the refrigerant.

[0018] In the case of the heat pump type hot water supply device, the indoor heat exchanger 6 is configured as a dual-pipe heat exchanger, a plate type heat exchanger, or a shell-tube type heat exchanger including a first flow path allowing the refrigerant to pass therethrough and a second flow path allowing a heating medium to pass therethrough, in which the refrigerant in the first flow path and the heating medium in the second flow path are heat-exchanged with a heat transmission member interposed therebetween, and in this case, the heating medium, passing through the second flow path, is heat-exchanged with the refrigerant through the heat transmission member.

[0019] The indoor heat exchanger 6 may be connected with a reservoir (or hot water tank) in which the heating medium is accommodated, through a heating medium circulation flow path, and as the heating medium flowing from the reservoir (or hot water tank) passes through the second flow path of the indoor heat exchanger 6, the refrigerant is evaporated or condensed.

[0020] The heat pump includes an expansion mechanism 8 installed between the indoor heat exchanger 6 and the outdoor heat exchanger 4 to expand a refrigerant.

[0021] The heat pump further includes a flow path switch 10 for allowing the refrigerant to circulate from the outdoor heat exchanger 4, to the expansion mechanism 8, and then to the indoor heat exchanger 6, or from the compressor 2, to the indoor heat exchanger 6, then to the expansion mechanism 8, and then to the outdoor heat exchanger 4.

[0022] The flow path switch 10 may be one 4-way valve that changes a flow direction of the refrigerant, or a plurality of switching valves that change the flow direction of the refrigerant. In the following description, it is assumed that one 4-way valve is used to change the flow direction of the refrigerant.

[0023] The heat pump may include an outdoor unit O including the compressor 2, the outdoor heat exchanger 4, the outdoor fan 5, the expansion mechanism 8, and the flow path switch 10, and an indoor unit I including the indoor heat exchanger 6 and the indoor fan 7.

[0024] In certain embodiments, the heat pump may perform a cooling operation and a heating operation. In alternative embodiments, the heat pump may perform the cooling operation, the heating operation, and a defrosting operation, or may perform the heating operation and the defrosting operation.

[0025] The cooling operation is performed to cool a heating medium or indoor air using the indoor heat exchanger 6. For the cooling operation, the refrigerant compressed in the compressor 2 flows to the outdoor heat exchanger 4, sequentially passes through the expansion mechanism 8 and the indoor heat exchanger 6, and then, is returned to the compressor 2.

[0026] The heating operation is performed to heat the heating medium or indoor air. For the heating operation, the refrigerant compressed in the compressor 2 flows to the indoor heat exchanger 6, sequentially passes through the expansion mechanism 8 and the outdoor heat exchanger 4, and then is returned to the compressor 2.

[0027] The defrosting operation is performed to eliminate frost generated at the outdoor heat exchanger 4 by directing compressed refrigerant to the outdoor heat exchanger 4. Like the cooling operation, in the defrosting operation, the refrigerant compressed in the compressor 2 flows to the outdoor heat exchanger 4, sequentially passes through the expansion mechanism 8 and the indoor heat exchanger 6, and then is returned to the compressor 2.

[0028] In the defrosting operation, a portion of the compressed refrigerant may pass through a portion of the flow path of the outdoor heat exchanger 4 to partially defrost the outdoor heat exchanger 4, and the remaining compressed refrigerant may sequentially pass through the indoor heat exchanger 6 and the expansion mechanism 8, pass through the remaining portion of the flow path of the outdoor heat exchanger 4, and then, may be returned to the compressor 2.

[0029] When a defrosting condition is met while the heating operation is being performed, the defrosting operation is performed. Thereafter, when a defrosting complete condition is met, the operation may be returned to the heating operation again.

[0030] The defrosting condition may include, for example, an accumulation of a predetermined amount of operation time of the heat pump in the heating operation, an outdoor temperature, a suction overheat degree, and the like, which triggers the need for defrosting setting conditions. Similarly, the defrosting complete condition may include, for example, a predetermined amount of time during which the heat pump has been operated in the defrosting operation, the outdoor temperature, the suction overheat degree, and the like, which indicates that defrosting is complete and the defrosting operation may be terminated.

[0031] When the heat pump is used to perform the heating operation, the flow path switch 10 directs the refrigerant compressed in the compressor 2 to the outdoor heat exchanger 4, and when the defrosting condition is met, the flow path switch 10 directs the refrigerant compressed in the compressor 2 to the indoor heat exchanger 6, and thereafter, when the heat pump is returned to the heating operation, the flow path switch 10 directs the compressed refrigerant compressed in the compressor 2 to the outdoor heat exchanger 4.

[0032] As shown in FIG. 2, the outdoor heat exchanger 4 may be configured as a fin-tube heat exchanger including a refrigerant tube 12 allowing a refrigerant to pass therethrough and one or more fins 14 coupled to the refrigerant tube 12. Outdoor air is heat-exchanged with the refrigerant through the one or more fins 14 and the refrigerant tube 12. Both water repellent coating material 16 and hydrophilic coating material 18 may be coated on the fins 14 of the outdoor heat exchanger 4.

[0033] In the exemplary embodiment shown in FIG. 2, the water repellent coating material 16 is coated on one surface of the fins 14 and the hydrophilic coating material 18 is coated on the other surface of the fins 14 (i.e., a surface opposite the surface on which the water repellent coating material is coated).

[0034] When the water repellent coating material 16 is coated on the fins 14 of the outdoor heat exchanger 4, frost

growth on the surface of the fins 14 may be delayed and a heating operation duration, without the need for a defrosting operation, may be lengthened. When the hydrophilic coating material 18 is coated on the fins 14 of the outdoor heat exchanger 4, frost melt during the defrosting operation may be more quickly accomplished, and a duration of the defrosting operation may be shortened.

[0035] In certain embodiments, the fins 14 may be coated with both the hydrophilic coating material 18 and the water repellent coating material 16 such that frost growth may be delayed and any accumulated frost may be defrosted within a shortened amount of time.

[0036] In a heat pump as embodied and broadly described herein, taking into consideration a ratio of an area on which the water repellent coating material 16 is coated (i.e., the heat transmission area of the water repellent coating air side) to an area of the fins 14 are in contact with air flowing through the heat exchanger (i.e., the heat transmission area of the overall air side), a duration of the heating operation may be affected as shown in FIG. 3 and a duration of the defrosting operation may be affected as shown in FIG. 4.

[0037] With reference to FIGS. 3 and 4, in order to shorten the duration of the defrosting operation while also lengthening the uninterrupted duration of the heating operation, the area of the fins 14 coated with the water repellent coating material 16 may be larger than the area coated with the hydrophilic coating material 18. In certain embodiments, the area of the fins 14 coated with the water repellent coating material 16 may be greater 0.5 times and less than 0.6 times the area of the fins 14 that is exposed to/is in contact with air.

[0038] If the area of the fins 14 coated with the water repellent coating material 16 is less than 0.5 times the area that is in contact with air, a corresponding duration of the heating operation may be too short, and when the area of the fins 14 coated with the water repellent coating material 16 is greater 0.6 times the area in contact with air, the duration of the heating operation duration may be lengthened, but in this case, the duration of the defrosting operation duration would also be lengthened. Thus, the area of the fins 14 coated with the water repellent coating material 16 is greater than 0.5 times but less than 0.6 times the area in contact with air.

[0039] Each of the fins 14 include a plate body 22 having two opposite faces thereof in contact with outdoor air and a collar 24 that protrudes in a cylindrical shape from the plate body 22 and coupled with the refrigerant tube 12.

[0040] Both faces of the plate body 22 may form outdoor air contact surfaces, and one of the two faces may be coated with the water repellent coating material 16 and the other may be coated with the hydrophilic coating material 18.

[0041] An inner circumferential surface A of the collar 24 may contact the refrigerant tube 12, and an outer circumferential face B of the collar 24 may make contact with outdoor air. In certain embodiments, the inner circumferential face A of the collar 24 may be coated with the hydrophilic coating material 18 and the outer circumferential face B of the collar 24 may be coated with the water repellent coating material 16.

[0042] The two opposite faces C and D of the plate body 22 may include one face D that extends outward from and is perpendicular to the outer circumferential face B of the collar 24 and which may be coated with the water repellent coating material 16. The opposite face C of the plate body 22 may be coated with the hydrophilic coating material 18, and may extend from and be perpendicular to the inner circumferential face A of the collar 24.

[0043] In the outdoor heat exchanger 4, a plurality of fins 14 may be coupled to the refrigerant tube 12 along a length of the refrigerant tube 12, separated from each other by a predetermined interval. As shown in FIG. 2, the collars 24 are coupled with the plurality of fins 14 and are arranged along the refrigerant tube 12 such that the collars 24 protrude in the same direction, and are arranged such that the water repellent coating material 16 and the hydrophilic coating material 18 may be positioned in order of water repellent coating material 16→hydrophilic coating material 18→water repellent coating material 16→hydrophilic coating material 18 in a direction perpendicular to the flow of outdoor air.

[0044] Namely, the hydrophilic coating material 18 coated on any one of the plurality of fins 14 is positioned to face the water repellent coating material 16 coated on any of the other of the plurality of fins 14, in particular, an adjacent fin 14, and condensation water between the fins 14 may be quickly discharged along the hydrophilic coating material 18.

[0045] FIG. 5 is an enlarged side view of condensation water generated on a water repellent coated surface of a fin of a heat pump as embodied and broadly described herein, and FIG. 6 is an enlarged side view of condensation water generated on a hydrophilic coated surface of a fin of a heat pump as embodied and broadly described herein.

[0046] In certain embodiments, the fins 14 of the outdoor heat exchanger 4 may be made of an aluminum material which may be relatively low-priced compared with a copper material. Such an aluminum material may include, for example, an aluminum alloy.

[0047] In order for the water repellent coating material 16 and the hydrophilic coating material 18 to satisfy appropriate durability conditions when they are coated on the fins 14 made of an aluminum material, the water repellent coating material 16 may be a coating material that meets the condition in which a contact angle  $E^\circ$  of condensation water W generated on the surface of the water repellent coating material 16 is greater than about  $90^\circ$  and is less than about  $150^\circ$  and the hydrophilic coating material 18 may be a coating material that meets the condition in which a contact angle  $F^\circ$  of condensation water W is greater than about  $0^\circ$  and is less than about  $30^\circ$ .

[0048] An outdoor heat exchanger and a heat pump having the same are provided a heating operation duration may be lengthened and heating performance may be enhanced.

[0049] A heat pump having an outdoor heat exchanger as embodied and broadly described herein may include a compressor compressing a refrigerant; an outdoor heat exchanger heat-exchanging the refrigerant with outdoor air; an indoor heat exchanger heat-exchanging the refrigerant with indoor air or a heating medium; and an expansion mechanism installed between the outdoor heat exchanger and the indoor heat exchanger to expand the refrigerant, wherein the outdoor heat exchanger includes a refrigerant tube in which the refrigerant passes and one or more fins coupled with the refrigerant tube, one face of each of the pins is coated with a water repellent coating material and the other face thereof is coated with a hydrophilic coating material, and an area coated with the water repellent coating material among the areas in contact with air is larger than an area coated with the hydrophilic coating material.

[0050] Each of the fins may include a plate body portion in contact with outdoor air and a collar protruded in a cylindrical shape from the plate body portion and having an inner circumferential face in contact with the refrigerant tube and an

outer circumferential face in contact with outdoor air. The outer circumferential face of the collar may be coated with the water repellent coating material. The inner circumferential face of the collar may be coated with the hydrophilic coating material.

[0051] A face of the plate body portion, among both faces of the plate body portion, extending to be perpendicular to the outer circumferential face of the collar may be coated with the water repellent coating material, and a face of the plate body portion, among the both faces of the plate body portion, extending to be perpendicular to the inner circumferential face of the collar may be coated with the hydrophilic coating material.

[0052] The area of the fins coated with the water repellent coating material may exceed 0.5 times and smaller than 0.6 times the area of the fins in contact with outdoor air.

[0053] The fins may be coupled with the refrigerant tube such that they are separated in a lengthwise direction of the refrigerant tube, and the hydrophilic coating material coated on any one of the plurality of fins may face the water repellent coating material coated on any the other of the plurality of fins.

[0054] In such an outdoor heat exchanger, the water repellent coating material and the hydrophilic coating material may be alternately positioned in a direction perpendicular to a direction in which outdoor air flows.

[0055] The fins may be made of an aluminum material.

[0056] The water repellent coating material may be a coating material making a contact angle of condensation water generated on a surface of the water repellent coating material exceed  $90^\circ$  and smaller than  $150^\circ$ .

[0057] The hydrophilic coating material may be a coating material making a contact angle of condensation water generated on a surface of the hydrophilic coating material exceed  $0^\circ$  and smaller than  $30^\circ$ .

[0058] In a heat exchanger as embodied and broadly described herein, since both the water repellent coating material and the hydrophilic coating material are both provided and the area coated with the water repellent coating material, among the areas in contact with air, is greater than the area coated with the hydrophilic coating material, a sufficient heating capacity may be secured in performing a heating operation.

[0059] Additionally, since the water repellent coating material is coated on the face of the collar in contact with air, concentration of frost on the collar may be minimized and defrosting can be quickly performed.

[0060] Further, the defrosting operation duration may be minimized while lengthening a heating operation duration.

[0061] Any reference in this specification to “one embodiment,” “an embodiment,” “example embodiment,” etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

[0062] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and

embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. A heat pump, comprising:
  - a compressor;
  - an outdoor heat exchanger that performs heat exchange between refrigerant and outdoor air;
  - an indoor heat exchanger that performs heat exchange between refrigerant and indoor air; and
  - an expander installed between the outdoor heat exchanger and the indoor heat exchanger, wherein the outdoor heat exchanger comprises:
    - a refrigerant tube that guides refrigerant therethrough;
    - one or more fins coupled to the refrigerant tube;
    - a water repellent coating material applied to a first surface of each of the one or more fins; and
    - a hydrophilic coating material applied to a second surface of each of the one or more fins, wherein an area coated with the water repellent coating material is greater than an area coated with the hydrophilic coating material.
2. The heat pump of claim 1, wherein each of the one or more fins comprises:
  - a substantially cylindrical collar having an inner circumferential surface thereof in contact with the refrigerant tube and an outer circumferential surface thereof exposed to air flowing through the outdoor heat exchanger, wherein the outer circumferential surface of the collar is coated with the water repellent coating material; and
  - a plate body that extends outward from the collar, the plate body being exposed to the air flowing through the outdoor heat exchanger.
3. The heat pump of claim 2, wherein the inner circumferential surface of the collar is coated with the hydrophilic coating material.
4. The heat pump of claim 2, wherein a first surface of the plate body that extends outward from and is perpendicular to the outer circumferential surface of the collar is coated with the water repellent coating material, and a second surface of the plate body that extends outward from and is perpendicular to the inner circumferential surface of the collar is coated with the hydrophilic coating material.
5. The heat pump of claim 1, wherein an area of each of the one or more fins coated with the water repellent coating material is greater than 0.5 times and less than 0.6 times a total area thereof that is exposed to the air flowing through the outdoor heat exchanger.
6. The heat pump of claim 1, wherein the one or more fins comprises a plurality of fins arranged at predetermined intervals along the refrigerant tube, and wherein the hydrophilic coating material coated on any one of the plurality of fins faces the water repellent coating material coated on an adjacent fin of the plurality of fins.
7. The heat pump of claim 6, wherein the water repellent coating material and the hydrophilic coating material are

alternately positioned in a direction perpendicular to an air flow direction in the outdoor heat exchanger.

8. The heat pump of claim 7, wherein each of the plurality of fins is made of an aluminum material.

9. The heat pump of claim 6, wherein a contact angle of condensation water generated on a surface of the water repellent coating material is greater than 90° and less than 150°.

10. The heat pump of claim 6, wherein a contact angle of condensation water generated on a surface of the hydrophilic coating material is greater than 0° and less than 30°.

11. A heat exchanger for a heat pump, comprising:

- a refrigerant tube that guides refrigerant through the heat exchanger; and
- a plurality of fins coupled to the refrigerant tube, each of the plurality of fins being made of an aluminum material, wherein each of the plurality of fins comprises:
  - a substantially cylindrical having an inner circumferential surface thereof fitted around the refrigerant tube and an outer circumferential surface thereof exposed to air flowing through the heat exchanger;
  - a plate body that extends outward from the collar and having first and second surfaces exposed to air flowing through the heat exchanger;
  - a water repellent material coated on one of the inner or outer circumferential surface of the collar and one of the first or second surface of the plate body extending respectively therefrom; and
  - a hydrophilic material coated on the other of the inner or outer surface of the collar and the other of the first or second surface of the plate body extending respectively therefrom.

12. The heat exchanger of claim 11, wherein the inner circumferential surface of the collar and the second surface of the plate body, which extends outward from and is perpendicular to the inner circumferential surface of the collar, of each of the plurality of fins are coated with the hydrophilic coating material.

13. The heat exchanger of claim 12, wherein the outer circumferential surface of the collar and the first surface of the plate body, which extends outward from and is perpendicular to the outer circumferential surface of the collar, of each of the plurality of fins are coated with the water repellent material.

14. The heat exchanger of claim 11, wherein an area of each of the plurality of fins that is coated with the water repellent coating material is greater than 0.5 times and less than 0.6 times an area of each of the plurality of fins that is exposed to air flowing through the heat exchanger.

15. The heat exchanger of claim 14, wherein the water repellent coating material and the hydrophilic coating material are alternately positioned in a direction perpendicular to an air flow direction in the heat exchanger.

16. The heat exchanger of claim 14, wherein a contact angle of condensation water generated on a surface of the water repellent coating material is greater than 90° and less than 150°, and a contact angle of condensation water generated on a surface of the hydrophilic coating material is greater than 0° and less than 30°.

17. A heat pump comprising the heat exchanger of claim 11.

18. An outdoor heat exchanger, comprising:

- a refrigerant tube that guides refrigerant therethrough and
- a plurality of fins coupled to the refrigerant tube, wherein each of the plurality of fins comprises:
  - a cylindrical fitted around the refrigerant tube; and

a plate body extending outward from and perpendicular to the collar, wherein a first surface of the collar and a first surface of the plate body extending directly outward from the first surface of the collar are coated with a water repellent coating material, and a second surface of the collar and a second surface of the plate body extending directly outward from the second surface of the collar are coated with a hydrophilic coating material.

**19.** The outdoor heat exchanger of claim **18**, wherein the second surface of the collar is an inner circumferential surface of the collar that is positioned against the refrigerant tube, and the second surface of the plate body extends directly outward from a corresponding edge of the collar, perpendicular to the inner circumferential surface of the collar.

**20.** The outdoor heat exchanger of claim **19**, wherein the first surface of the collar is an outer circumferential surface of the collar opposite the inner circumferential surface thereof,

and wherein the first surface of the plate body extends outward from the outer circumferential surface of the collar, perpendicular to the outer circumferential surface of the collar.

**21.** The outdoor heat exchanger of claim **19**, wherein an area of each of the plurality of fins that is coated with the water repellent coating material is greater than 0.5 times and less than 0.6 times an area of each of the plurality of fins exposed to outdoor air flowing through the outdoor heat exchanger.

**22.** The outdoor heat exchanger of claim **21**, wherein a contact angle of condensation water generated on a surface of the water repellent coating material is greater than 90° and less than 150°, and a contact angle of condensation water generated on a surface of the hydrophilic coating material is greater than 0° and less than 30°.

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