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(54) **HEAT PUMP SYSTEM FOR VEHICLE AND METHOD OF CONTROLLING THE SAME**

(71) Applicant: **Hyundai Motor Company**, Seoul (KR)

(72) Inventor: **Jae Yeon KIM**, Hwaseong-si (KR)

(73) Assignee: **Hyundai Motor Company**, Seoul (KR)

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(57) **ABSTRACT**

A heat pump system for a vehicle may include a cooling apparatus that supplies and circulates coolant to a motor and an electrical equipment through a cooling line, wherein the cooling apparatus includes a radiator, a cooling fan that ventilates wind to the radiator, and a water pump connected to the cooling line, and an air conditioner apparatus connected through a refrigerant line, wherein the air conditioner apparatus includes a water-cooled condenser connected to the cooling line to change a temperature of the coolant using a waste heat that has occurred in the motor and the electrical equipment according to each mode of the vehicle and that is connected to the refrigerant line to enable an injected refrigerant in the refrigerant line to exchange a heat with the coolant at the inside thereof, and an air-cooled condenser connected in series to the water-cooled condenser through the refrigerant line.

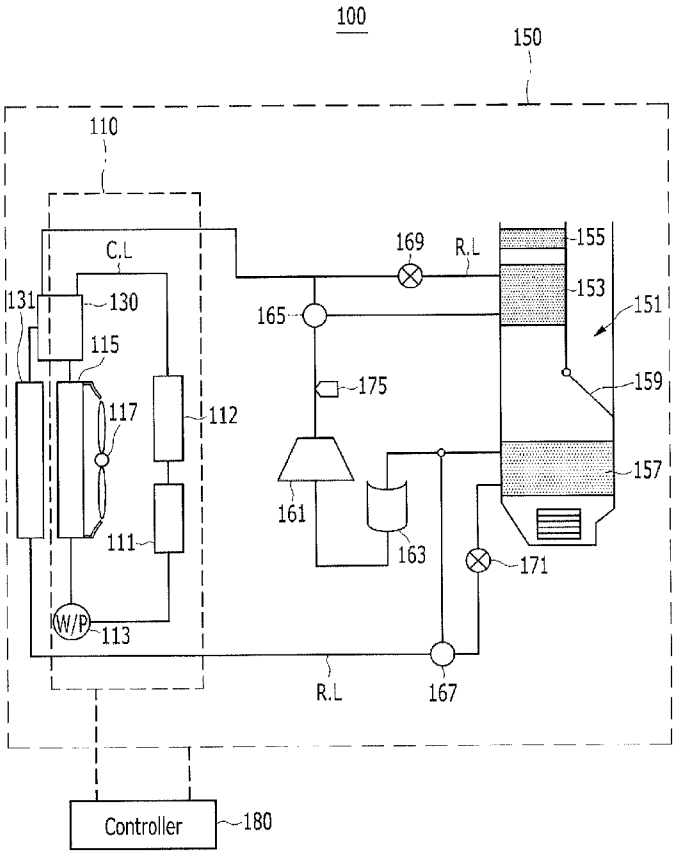
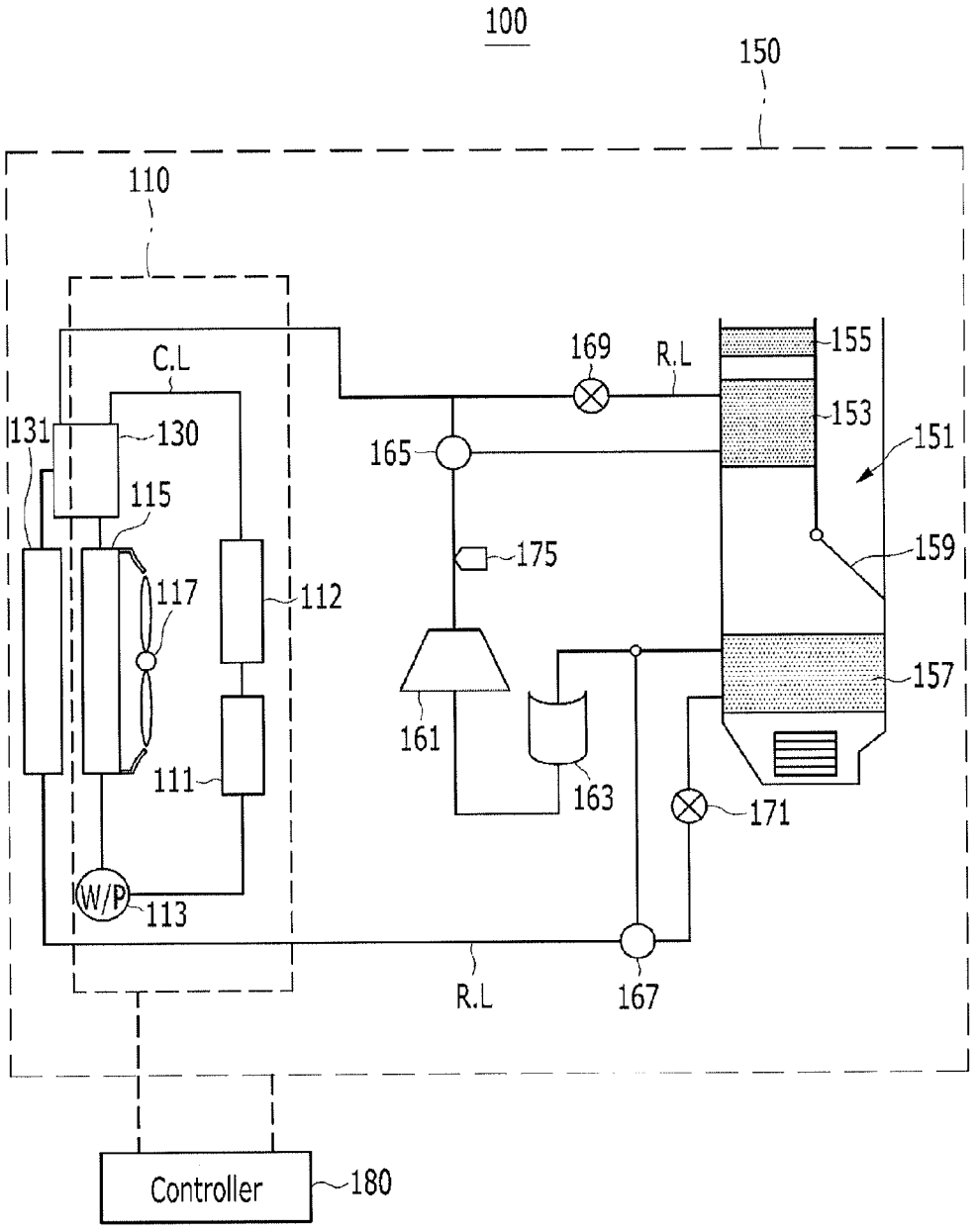


FIG. 1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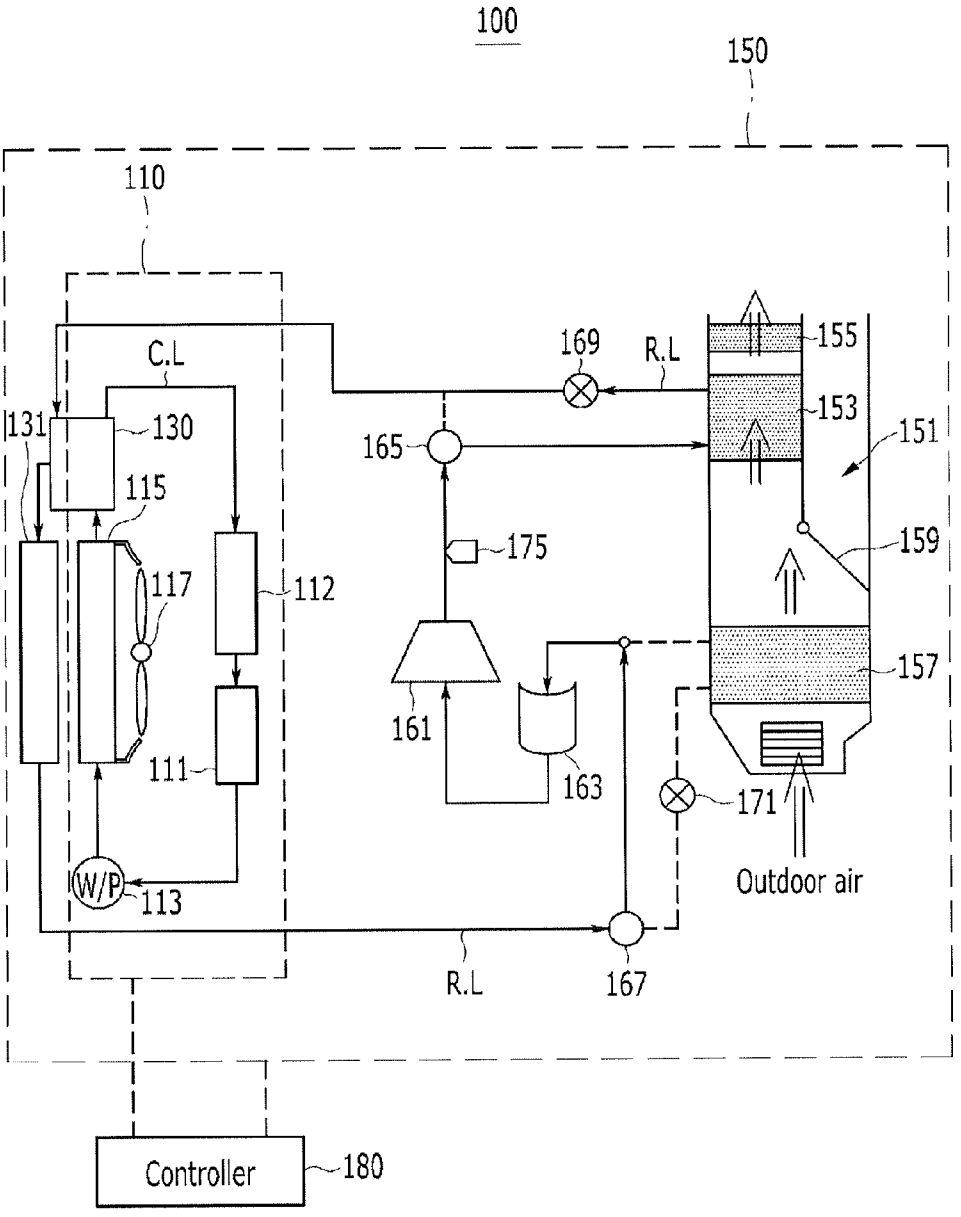
157
171
R.L
167
Controller
180

FIG. 2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Outdoor air
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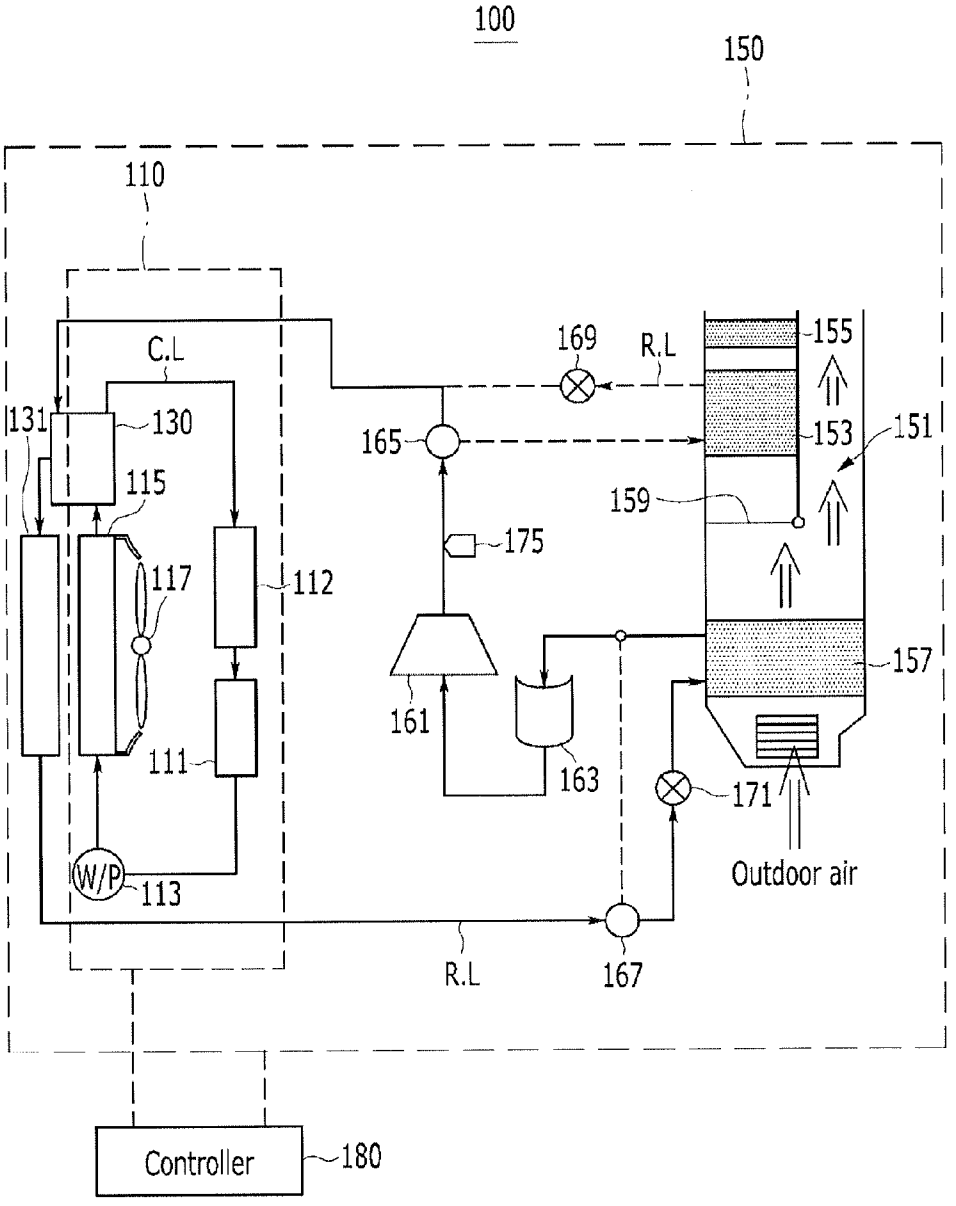
FIG. 3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Outdoor air
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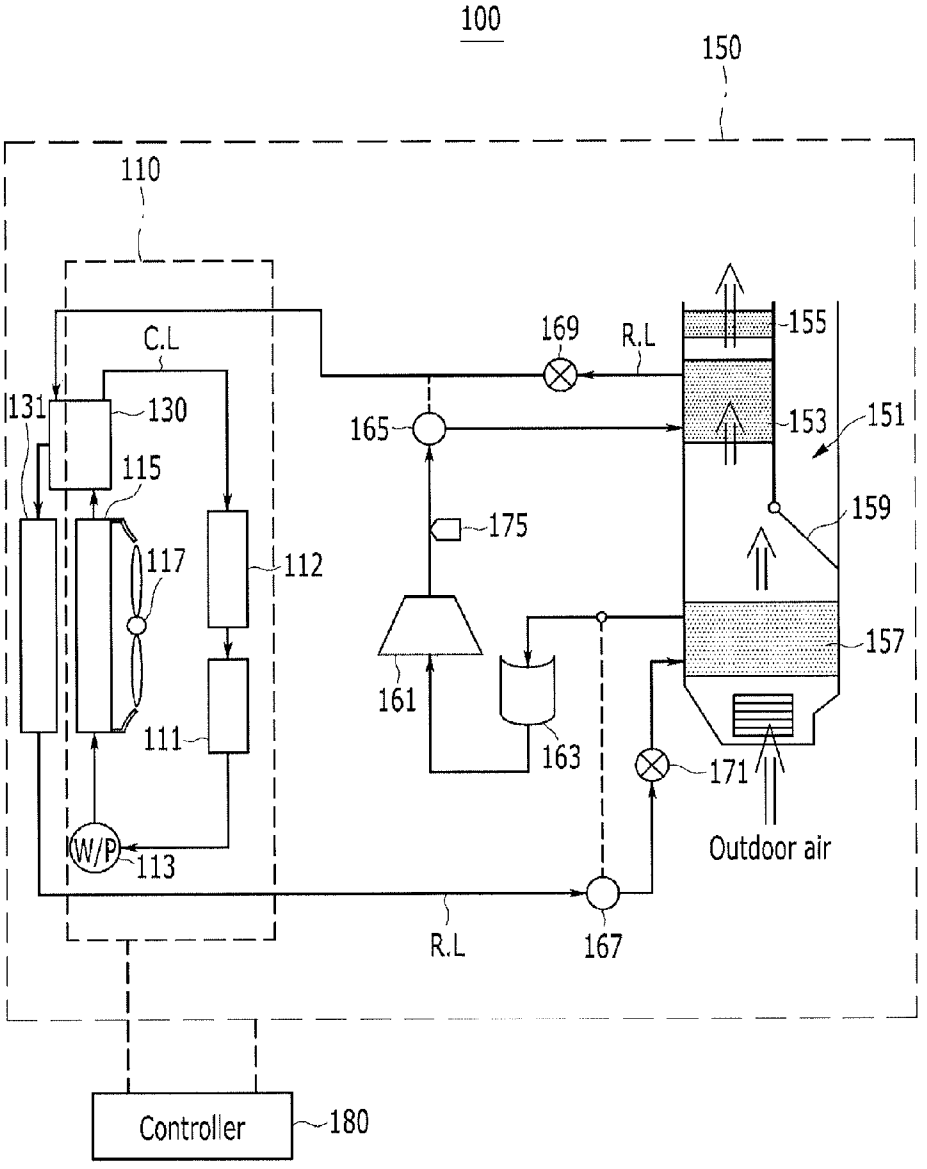
FIG. 4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Outdoor air
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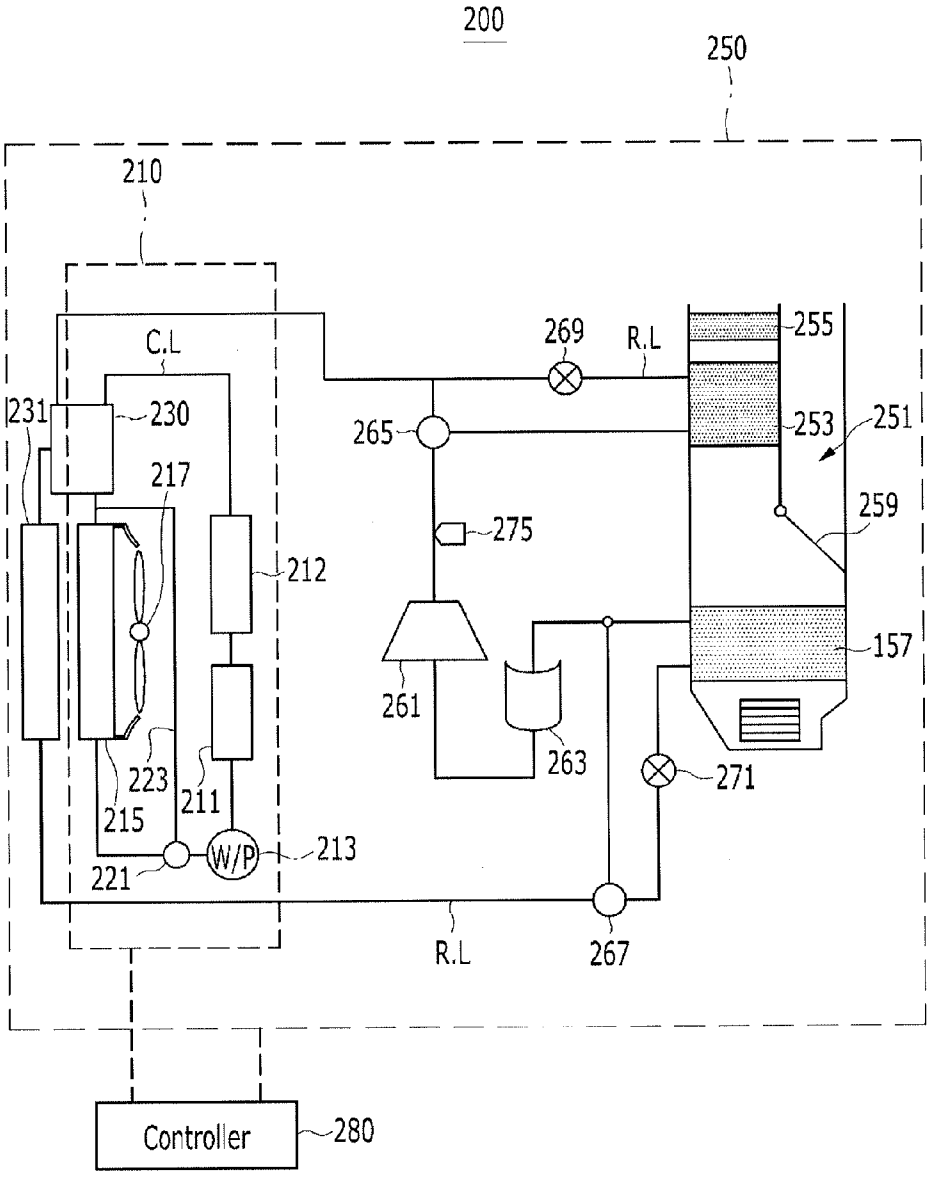
FIG. 5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W/P
213
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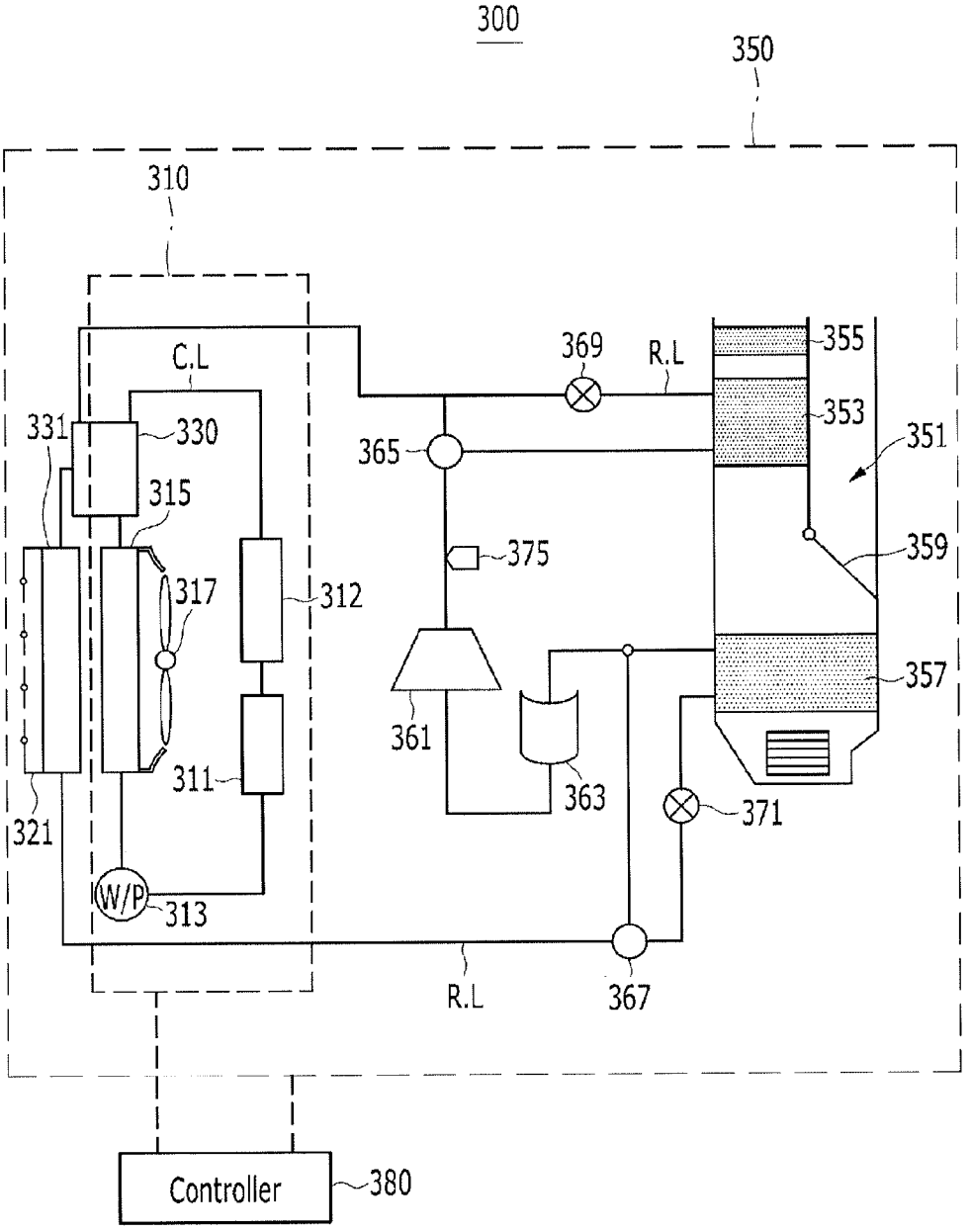
R.L
267
Controller
280

FIG. 6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371
321
W/P
313
R.L
367
Controller
380

HEAT PUMP SYSTEM FOR VEHICLE AND METHOD OF CONTROLLING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority to Korean Patent Application No. 10-2012-0099535 filed on Sep. 7, 2012, the entire contents of which is incorporated herein for all purposes by this reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a heat pump system for a vehicle and a method of controlling the same that simultaneously use a water heat source and an air heat source and that improve a heating performance and a dehumidification performance using a waste heat occurring in a motor and an electrical equipment.

[0004] 2. Description of Related Art

[0005] In general, an air-conditioning apparatus for a vehicle includes an air conditioner module for heating and air conditioning indoors of the vehicle.

[0006] In such an air conditioner module, a heat exchange medium that is ejected by driving of a compressor circulates again to the compressor via a condenser, a receiver drier, an expansion valve, and an evaporator. In this process, the air conditioner module air-conditions indoors of the vehicle by heat exchange by the evaporator or heats indoors of the vehicle by exchanging a heat by injecting high temperature coolant into a heater.

[0007] An environmentally-friendly vehicle is generally classified into an electric vehicle that drives using a fuel cell or electricity as a power source and a hybrid vehicle that drives using engine and an electric battery.

[0008] In such environmentally-friendly vehicles, the electric vehicle includes a heat pump system.

[0009] In the electric vehicle, in a heating mode, a gas refrigerant of a high temperature and a high pressure flows to an indoor condenser through a valve and exchanges a heat with inhaled outdoor air, and outdoor air in which a heat is exchanged is injected into indoors of the vehicle while passing through a positive temperature coefficient (PTC) heater, thereby raising a temperature of vehicle indoors.

[0010] However, as described above, as a structure of a compressor, a heat exchanger, and each constituent element becomes complicated, there is a problem that entire system package becomes complicated.

[0011] Further, as surface freezing occurs at an external condenser at a winter season, heat exchange efficiency, a heating performance, and efficiency of a heat exchange medium are deteriorated, and when an air conditioning mode is converted to a heating mode, humidity increases by condensation water remaining at the outside of an evaporator, and thus windowpanes of the vehicle are steamed up.

[0012] In a defrost mode that removes surface freezing of an external condenser in order to prevent this problem, operation of a compressor is stopped and heating should be performed with only a PTC heater, and thus while a heating performance is extremely deteriorated, when a heating load increases according to increase of a power use amount and the vehicle drives while heating, there is a problem that a travel distance is shortened.

[0013] Further, when an outdoor temperature is low, a heating performance is remarkably low and a system is unstable, and when a liquid refrigerant is injected into the compressor, durability of the compressor is deteriorated.

[0014] The information disclosed in this Background of the Invention section is only for enhancement of understanding of the general background of the invention and should not be taken as an acknowledgement or any form of suggestion that this information forms the prior art already known to a person skilled in the art.

BRIEF SUMMARY

[0015] Various aspects of the present invention are directed to providing a heat pump system for a vehicle and a method of controlling the same having advantages of simultaneously using a water heat source and an air heat source, improving a heating performance and a dehumidification performance using a waste heat occurring in a motor and an electrical equipment, and preventing external frost of an external condenser in an ultra low temperature.

[0016] The present invention has been made in an effort to further provide a heat pump system for a vehicle and a method of controlling the same having advantages of increasing an entire travel distance of the vehicle with the same power by reducing a heating load that may occur in a heating mode of the vehicle.

[0017] In an aspect of the present invention, a heat pump system for a vehicle, may include a cooling apparatus that supplies and circulates coolant to a motor and an electrical equipment through a cooling line, wherein the cooling apparatus may include a radiator that cools the supplied coolant through heat exchange with outdoor air, a cooling fan that ventilates wind to the radiator, and a water pump that is connected to the cooling line and circulates the coolant along the cooling line, and an air conditioner apparatus that is connected through a refrigerant line in order to adjust heating and air conditioning of vehicle indoors, wherein the air conditioner apparatus may include a water-cooled condenser that is connected to the cooling line to change a temperature of the coolant using a waste heat that may have occurred in the motor and the electrical equipment according to each mode of the vehicle and that is connected to the refrigerant line to enable an injected refrigerant in the refrigerant line to exchange a heat with the coolant at the inside thereof, and an air-cooled condenser that is connected in series to the water-cooled condenser through the refrigerant line and that enables a refrigerant that is injected into the inside thereof to exchange a heat with the outdoor air.

[0018] The air conditioner apparatus may include a heating, ventilation, and air conditioning (HVAC) module having a switch door that selectively adjusts opening at the inside thereof in order to inject outdoor air having passed through an evaporator according to a heating mode, an air conditioning mode, and a dehumidification mode into an internal condenser and a positive temperature coefficient (PTC) heater, a compressor that is connected to the evaporator through the refrigerant line and that compresses a refrigerant of a gas state, an accumulator that is provided on the refrigerant line between the compressor and the evaporator and that supplies a gas refrigerant to the compressor, a first valve that selectively supplies a refrigerant that is exhausted from the compressor to the water-cooled condenser or the internal condenser according to a mode of the vehicle, a first expansion valve that receives and expands a refrigerant having passed

through the internal condenser, a second valve that enables a refrigerant that is expanded through the first expansion valve to sequentially pass through the water-cooled condenser and the air-cooled condenser and that selectively supplies the refrigerant to the evaporator or the accumulator, and a second expansion valve that is provided between the evaporator and the second valve and that expands a refrigerant that is injected through switch of the second valve.

[0019] A pressure sensor is mounted on a refrigerant line that connects the compressor and the first valve.

[0020] The first and second, and three valves are formed with a 3-way valve.

[0021] The cooling apparatus and the air conditioner apparatus are operated by a control signal of a controller.

[0022] The cooling apparatus may further include a branch line that is installed on the cooling line between the water pump and the radiator and that bypasses the cooling line in order to directly supply coolant that is supplied from the water pump to the water-cooled condenser according to a heating mode, an air conditioning mode, and a dehumidification mode of the vehicle, and a third valve that selectively connects the cooling line and the branch line.

[0023] The third valve is formed with a 3-way valve.

[0024] The air-cooled condenser may have a plurality of switch films that selectively inject outdoor air at the front thereof.

[0025] The switch film operates by a control signal of a controller, is closed in a heating mode, and is opened in an air conditioning mode and a dehumidification mode.

[0026] In another aspect of the present invention, a method of controlling a heat pump system for a vehicle having a cooling apparatus that is electrically connected to a controller and that is fluid-connected through a cooling line and that may include a radiator, a water pump, and an electrical equipment, and an air conditioner apparatus that is connected through a refrigerant line and that may include a heating, ventilation, and air conditioning (HVAC) module that is formed with a plurality of valves, an expansion valve, a compressor, an accumulator, an evaporator, an internal condenser, a positive temperature coefficient (PTC) heater, and a switch door, may include operating the heat pump system, in a heating mode, an air conditioning mode, and a dehumidification mode according to a user's selection, wherein the heat pump system may include a water-cooled condenser that is connected to the cooling line and the refrigerant line and an air-cooled condenser that is disposed at the front of the radiator and connected to the refrigerant line, and changing a moving path of a refrigerant that circulates the air conditioner apparatus based on the heating mode, the air conditioning mode, and the dehumidification mode according to the user's selection, through operation of the each valve, such that a switch door of the HVAC module is selectively open and closed.

[0027] In the heating mode, by the cooling apparatus, raising a temperature of coolant that is injected into the water-cooled condenser through a waste heat that may have occurred in the motor and the electrical equipment, enabling the coolant to exchange a heat with a refrigerant that is injected into the water-cooled condenser through the refrigerant line, injecting the refrigerant having passed through the water-cooled condenser into the air-cooled condenser, and enabling the refrigerant to exchange a heat with a heat source of outdoor air, and in the heating mode, by the air conditioner apparatus, enabling a heated refrigerant through heat exchange with coolant and outdoor air in the water-cooled condenser and the air-cooled condenser, supplying the refrigerant to the internal condenser of the HVAC module through operation of the first valve in a state that is compressed with a gas refrigerant of a high temperature and high pressure state by passing through the accumulator and the compressor along a refrigerant line through opening of the second valve, sequentially supplying and circulating the refrigerant having passed through the internal condenser to the water-cooled condenser and the air-cooled condenser in a state that is expanded through the first expansion valve, and opening the switch door so that outdoor air, having passed through the evaporator of the HVAC module from the outside passes through the internal condenser, and enabling the injected outdoor air to heat vehicle indoors together with a selective operation of the PTC heater while passing through the internal condenser.

[0028] In the air conditioning mode, cooling coolant that is injected into the radiator together with outdoor air by a cooling fan, and by the cooling apparatus lowering a temperature of a refrigerant by second heat exchange with outdoor air by injecting a refrigerant that may have exchanged a heat with coolant while passing through the water-cooled condenser into the air-cooled condenser while cooling the electrical equipment and the motor by circulating the coolant along the cooling line in a state that is cooled through heat exchange with a refrigerant that is injected into the water-cooled condenser, and by the air conditioner apparatus supplying an expanded refrigerant to the evaporator by operating the second valve so that a refrigerant of a low temperature that is cooled while passing through the air-cooled condenser injects into the second expansion valve that is connected to the evaporator of the HVAC module, exhausting the refrigerant that is evaporated through heat exchange with outdoor air in the evaporator, opening a refrigerant line that is connected to the water-cooled condenser through operation of the first valve and circulates the refrigerant in a state that is compressed while passing through the accumulator and the compressor, and cooling the vehicle indoors by closing the switch door so that outdoor air that is cooled while passing through the evaporator by a refrigerant that is injected into the evaporator is not injected into the internal condenser and by directly injecting outdoor air that is cooled while passing through the evaporator into the vehicle.

[0029] In the air conditioning mode, when the vehicle travels, opening each switch film that is installed at a front surface of the radiator to inject traveling wind into the radiator.

[0030] In the dehumidification mode, as a cooling fan operates, in a state in which coolant that is injected into the radiator together with outdoor air is cooled, by the cooling apparatus, cooling the motor and the electrical equipment through operation of the water pump with cooled coolant while lowering a temperature of a refrigerant and coolant by heat exchange of the refrigerant and the coolant of a low temperature that is injected into the water-cooled condenser, by the air conditioner apparatus, opening the second valve so that a refrigerant of a low temperature that is cooled while exchanging a heat with coolant and outdoor air while sequentially passing through the water-cooled condenser and the air-cooled condenser is injected into the second expansion valve that is connected to the evaporator of the HVAC module, supplying the expanded refrigerant to the evaporator, supplying a refrigerant to the internal condenser by opening a refrigerant line that is connected to the internal condenser

through operation of the first valve in a compressed state while passing through the accumulator and the compressor by exhausting a refrigerant that is evaporated through heat exchange with outdoor air in the evaporator, supplying and circulating the refrigerant having passed through the internal condenser to the water-cooled condenser in a state that is expanded through the first expansion valve, opening the switch door so that outdoor air that is cooled while passing through the evaporator of the HVAC module from the outside passes through the internal condenser, and enabling injected outdoor air to dehumidify vehicle indoors while passing through the internal condenser and the PTC heater.

[0031] In the dehumidification mode, adjusting, by the controller, an expansion amount of the refrigerant through adjustment of opening of the first and second expansion valves.

[0032] In the dehumidification mode, when the vehicle travels, opening each switch film that is installed at a front surface of the radiator to inject traveling wind into the radiator.

[0033] In the heating mode, the air conditioning mode, and the dehumidification mode, controlling, by the controller, a wind amount of the cooling fan and a flux of the water pump according to a temperature state of a waste heat that may have occurred in the electrical equipment and a temperature state of the coolant and the refrigerant.

[0034] As described above, in a heat pump system for a vehicle and a method of controlling the same according to an exemplary embodiment of the present invention, the vehicle heat pump system includes a water-cooled condenser using coolant as a heat exchange medium and an air-cooled condenser using an air heat source, makes a refrigerant to flow in series, and uses a waste heat source occurring in a motor and an electrical equipment and a heat source of outdoor air, thereby improving an entire heating performance, efficiency, and a dehumidification performance and preventing external frost of the air-cooled condenser in an ultra low temperature.

[0035] Further, as a user operates a heating mode by using a waste heat source without operation of a PTC heater or by using together a waste heat source and a PTC heater according to a peripheral environment of the vehicle, there is a merit that an entire travel distance of the vehicle increases with the same power by reducing a heating load while a power use amount is prevented from increasing, and an entire market value of the heat pump system can be improved.

[0036] In an air conditioning mode of the vehicle, in a low speed driving condition, in IDLE and low speed driving conditions, which is a condition in which an electric heat amount of a motor and an electrical equipment is small, but that has a large air conditioner electric heat amount, a temperature of coolant that is injected into a water-cooled condenser is lowered, and by increasing a refrigerant condensation amount through simultaneous application of the water-cooled condenser and the air-cooled condenser, an air conditioning performance can be improved.

[0037] In a dehumidification mode, by reducing a frequent valve switch operation through application of a 3-way valve, occurrence of noise and a vibration can be reduced due to a valve switch operation, and because a dehumidification mode can continuously use in intermediate temperature and much moisture conditions, a remaining amount of condensation water reduces according to decrease of indoor humidity, and thus a moisture occurrence condition can be reduced.

[0038] Further, by together using outdoor air and coolant as a heat exchange medium of condensers, while a structure of each constituent element is simplified, a motor and an electrical equipment can be cooled with one radiator, and entire system package can be reduced and efficiency of a radiator can be improved through reduction of ventilation resistance.

[0039] Further, by exchanging a heat of coolant and a refrigerant using a waste heat that has occurred in a motor and an electrical equipment in a water-cooled condenser, a heat exchange performance can be previously prevented from being deteriorated by external freezing that has occurred when a conventional air-cooled condenser is individually applied in an ultra low temperature condition, and even if a separate defrost mode does not exist, external frost of an air-cooled condenser can be prevented.

[0040] The methods and apparatuses of the present invention have other features and advantages which will be apparent from or are set forth in more detail in the accompanying drawings, which are incorporated herein, and the following Detailed Description, which together serve to explain certain principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] FIG. **1** is a block diagram illustrating a heat pump system for a vehicle according to various exemplary embodiments of the present invention.

[0042] FIG. **2** is a diagram illustrating a heating mode operation state of a heat pump system for a vehicle according to various exemplary embodiments of the present invention.

[0043] FIG. **3** is a diagram illustrating an air conditioning mode operation state of a heat pump system for a vehicle according to various exemplary embodiments of the present invention.

[0044] FIG. **4** is a diagram illustrating a dehumidification mode operation state of a heat pump system for a vehicle according to various exemplary embodiments of the present invention.

[0045] FIG. **5** is a block diagram illustrating a heat pump system for a vehicle according to various exemplary embodiments of the present invention.

[0046] FIG. **6** is a block diagram illustrating a heat pump system for a vehicle according to various exemplary embodiments of the present invention.

[0047] It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various features illustrative of the basic principles of the invention. The specific design features of the present invention as disclosed herein, including, for example, specific dimensions, orientations, locations, and shapes will be determined in part by the particular intended application and use environment.

[0048] In the figures, reference numbers refer to the same or equivalent parts of the present invention throughout the several figures of the drawing.

DETAILED DESCRIPTION

[0049] Reference will now be made in detail to various embodiments of the present invention(s), examples of which are illustrated in the accompanying drawings and described below. While the invention(s) will be described in conjunction with exemplary embodiments, it will be understood that the present description is not intended to limit the invention(s) to those exemplary embodiments. On the contrary, the invention(s) is/are intended to cover not only the exemplary embodiments, but also various alternatives, modifications,

equivalents and other embodiments, which may be included within the spirit and scope of the invention as defined by the appended claims.

[0050] An exemplary embodiment of the present invention will hereinafter be described in detail with reference to the accompanying drawings.

[0051] Before a description, an exemplary embodiment that is described in this specification and a configuration that is shown in the drawings are only an exemplary embodiment of the present invention and do not represent the entire spirit and scope of the invention and thus it should be understood that various modifications and exemplary variations that can replace the exemplary embodiment and the configuration may exist at an application time point of the present invention.

[0052] FIG. **1** is a block diagram illustrating a heat pump system for a vehicle according to a first exemplary embodiment of the present invention.

[0053] Referring to FIG. **1**, in a vehicle heat pump system **100** and a method of controlling the same according to an exemplary embodiment of the present invention, the vehicle heat pump system **100** has a structure that can simultaneously use a water heat source and an air heat source, improve a heating performance and a dehumidification performance using a waste heat occurring in a motor **111** and an electrical equipment **112**, and prevent external frost of an external condenser in an ultra low temperature.

[0054] Further, the vehicle heat pump system **100** has a structure that can increase an entire travel distance of the vehicle with the same power by reducing a heating load that may occur in a heating mode of the vehicle.

[0055] For this purpose, as shown in FIG. **1**, the vehicle heat pump system **100** according to an exemplary embodiment of the present invention includes a cooling apparatus **110** that supplies coolant to a motor **111**, an electrical equipment **112**, and an engine and circulates the coolant through a cooling line (hereinafter, referred to as a 'C.L') in which coolant flows and an air conditioner apparatus **150** that is connected through a refrigerant line (hereinafter, referred to as an 'R.L') in which a refrigerant flows in order to adjust heating and air conditioning of vehicle indoors.

[0056] In the present exemplary embodiment, the cooling apparatus **110** includes a radiator **115** that is provided at the front of the vehicle and that circulates coolant along the C.L through operation of a water pump **113** and that cools the supplied coolant through a heat exchange with outdoor air and a cooling fan **117** that is mounted at the rear of the radiator **115** to ventilate wind to the radiator **115**.

[0057] The heat pump system **100** according to the present exemplary embodiment further includes a water-cooled condenser **130** to which the C.L and the R.L are each connected and an air-cooled condenser **131** that is connected to the water-cooled condenser **130** through the R.L.

[0058] First, the water-cooled condenser **130** is connected to the C.L to change a temperature of coolant using a waste heat occurring in the motor **111** and the electrical equipment **112** according to each mode of the vehicle, and the water-cooled condenser **130** is connected to the R.L to enable an injected refrigerant to exchange a heat with the coolant at the inside thereof.

[0059] Here, the water-cooled condenser **130** has a temperature sensor at the inside thereof, and the temperature sensor senses a water temperature of injected coolant and a temperature of a refrigerant.

[0060] In the present exemplary embodiment, the water-cooled condenser **130** is separately provided from the radiator **115** to be connected through the C. L, but the present invention is not limited thereto and the water-cooled condenser **130** may be integrally formed at the inside of the radiator **115**.

[0061] In the present exemplary embodiment, the air-cooled condenser **131** is coupled in series to the water-cooled condenser **130** through the R.L and is disposed at the front of the radiator **115** to enable a refrigerant that is injected into the inside to exchange a heat with outdoor air.

[0062] In the present exemplary embodiment, the air conditioner apparatus **150** includes a heating, ventilation, and air conditioning (HVAC) module **151**, a compressor **161**, an accumulator **163**, first and second valves **165** and **167**, and first and second expansion valves **169** and **171**, and hereinafter, each constituent element will be described in detail.

[0063] First, in order to inject outdoor air, having passed through an evaporator **157** into an internal condenser **153** and a PTC heater **155** according to air conditioning, heating, and dehumidification modes, the HVAC module **151** has a switch door **159** that selectively adjusts opening at the inside thereof.

[0064] That is, the switch door **159** is opened to inject outdoor air, having passed through the evaporator **157** into the internal condenser **153** and the PTC heater **155** upon heating the vehicle and closes the internal condenser **153** and the PTC heater **155** in order to directly inject outdoor air that is cooled while passing through the evaporator **157** into the vehicle upon air conditioning.

[0065] In the present exemplary embodiment, the compressor **161** is connected to the evaporator **157** through the R.L and compresses a refrigerant of a gas state.

[0066] The accumulator **163** is provided on the R.L between the compressor **161** and the evaporator **157**, stores a liquid refrigerant at the inside thereof in order to supply only a gas refrigerant to the compressor **161**, vaporizes the stored liquid refrigerant, and supplies again a gas refrigerant to the compressor **161**, thereby improving efficiency and durability of the compressor **161**.

[0067] In the present exemplary embodiment, the first valve **165** selectively supplies a refrigerant that is exhausted from the compressor **161** to the internal condenser **153** according to a mode of the vehicle, and the first expansion valve **169** receives and expands a refrigerant, having passed through the internal condenser **153**.

[0068] In the present exemplary embodiment, the first valve **165** selectively supplies a refrigerant that is exhausted from the compressor **161** to the water-cooled condenser **130** or the internal condenser **153** according to a mode of the vehicle.

[0069] The first expansion valve **169** receives and expands the refrigerant, having passed through the internal condenser **153** through the R.L.

[0070] Here, a pressure sensor **175** is mounted on the R.L between the compressor **161** and the first valve **165** and senses a pressure of a refrigerant that is exhausted in a state that is compressed by the compressor **161**.

[0071] The second valve **167** enables a refrigerant that is expanded through the second expansion valve **171** to sequentially pass through the water-cooled condenser **130** and the air-cooled condenser **131** and selectively supplies the refrigerant to the evaporator **157** or the accumulator **163**.

[0072] The second expansion valve **171** is provided between the evaporator **157** and the second valve **167**,

expands a refrigerant that is injected through switch of the second valve **167**, and supplies the refrigerant to the evaporator **157**.

[0073] Here, the first valve **165** supplies a refrigerant to the water-cooled condenser **130** or the internal condenser **153**, and the second valve **167** is preferably formed with a 3-way valve that selectively switches and connects the R.L in order to supply the refrigerant to the accumulator **163** or the second expansion valve **171**.

[0074] The cooling apparatus **110** and the air conditioner apparatus **150** having the above-described configuration are each connected to a controller **180** and operate by a control signal of the controller **180**.

[0075] That is, the controller **180** controls the cooling fan **117** of the cooling apparatus **110** and the water pump **113** according to a heating mode, an air conditioning mode, and a dehumidification mode of the vehicle by a user's selection and a signal that is output from a temperature sensor of the condenser **130**.

[0076] Further, while controlling a switch operation of the switch door **159** of the HVAC module **151** in the air conditioner apparatus **150** according to a mode of the vehicle, the controller **180** controls a switch operation of the first and second valves **165** and **167** and controls an expansion amount of a refrigerant by controlling the first and second expansion valves **169** and **171**.

[0077] Hereinafter, operation of a vehicle heater pump system and a method of controlling the vehicle heater pump system having the above-described configuration according to an exemplary embodiment of the present invention will be described in detail with reference to FIGS. **2** to **4**.

[0078] FIGS. **2** to **4** are diagrams illustrating an operation state in a heating mode, an air conditioning mode, and a dehumidification mode of a heat pump system for a vehicle according to a first exemplary embodiment of the present invention.

[0079] First, a method of controlling a heat pump system for a vehicle according to a first exemplary embodiment of the present invention is applied to the heat pump system **100** including the cooling apparatus **110** that is connected to the controller **180** and that is connected through the C.L and that includes the radiator **115**, the water pump **113**, the motor **111**, and the electrical equipment **112** and the air conditioner apparatus **150** that is connected through the R.L and that includes the HVAC module **151** that is formed with the plurality of valves **165** and **167**, the expansion valves **169** and **171**, the compressor **161**, the accumulator **163**, the evaporator **157**, the internal condenser **153**, the PTC heater **155**, and the switch door **159**.

[0080] Here, as described above, the heat pump system **100** further includes the water-cooled condenser **130** that is connected to the C.L and the R.L and the air-cooled condenser **131** that is disposed at the front of the radiator **115** and that is coupled in series to the water-cooled condenser **130** through the R.L.

[0081] In the method of controlling the heat pump system **100**, a moving path of a refrigerant that circulates the air conditioner apparatus **150** on a mode basis according to a user's selection is changed through operation of the valves **165** and **167**, and the switch door **159** of the HVAC module **151** is selectively opened and closed.

[0082] That is, a heating mode, an air conditioning mode, and a dehumidification mode of the heat pump system **100** according to an exemplary embodiment of the present invention may be operated according to a user's selection or automatic adjustment.

[0083] First, in a heating mode of the heat pump system **100**, operation of the heat pump system **100** and a method of controlling the heat pump system **100** will be described with reference to FIG. **2**.

[0084] Referring to FIG. **2**, in a heating mode, the cooling apparatus **110** raises a temperature of coolant that is injected into the water-cooled condenser **130** using a waste heat occurring in the motor **111** and the electrical equipment **112** and enables the coolant to exchange a heat with a refrigerant that is injected into the water-cooled condenser **130** through the R.L.

[0085] The refrigerant, having passed through the water-cooled condenser **130** is injected into the air-cooled condenser **131** and is condensed through heat exchange with outdoor air while passing through the air-cooled condenser **131**.

[0086] In this case, as operation of the cooling fan **117** is stopped or as a wind velocity of the cooling fan **117** is deteriorated, cooling of coolant that is injected into the radiator **115** is delayed or prevented.

[0087] In such a state, the water-cooled condenser **130** raises a temperature of a refrigerant through heat exchange with the refrigerant that is injected through the R.L.

[0088] Here, the controller **180** determines a temperature of coolant and a refrigerant through a temperature sensor that is mounted in the water-cooled condenser **130**, and controls a flux of the water pump **113** or a wind amount of the cooling fan **117** according to a temperature state of a waste heat that has occurred in the motor **111** and the electrical equipment **112**, a temperature state of coolant, and a pressure state of a refrigerant.

[0089] The air conditioner apparatus **150** enables a refrigerant that is heated through heat exchange with coolant and outdoor air in the water-cooled condenser **130** and the air-cooled condenser **131**, respectively to pass through the accumulator **163** and the compressor **161** along the R.L through opening of the second valve **167**.

[0090] Accordingly, in a state that is compressed in a gas refrigerant of a high temperature and high pressure state while passing through the compressor **161**, as the R.L that is connected to the internal condenser **153** is opened by the first valve **165**, the refrigerant is supplied to the internal condenser **153**.

[0091] Here, the pressure sensor **175** that is mounted on the R.L between the compressor **161** and the first valve **165** measures a pressure of a refrigerant that is exhausted from the compressor **161** and outputs a measured value thereof to the controller **180**.

[0092] The controller **180** determines a pressure of a refrigerant according to the measured value that is output from the pressure sensor **175** and adjusts opening of the first valve **165** according to a requested vehicle state.

[0093] The refrigerant, having passed through the internal condenser **153** moves along the R.L in a state that is expanded through the first expansion valve **169**, sequentially passes through the water-cooled condenser **130** and the air-cooled condenser **131**, and circulates along the R.L through repetition of the above-described operation.

[0094] That is, in a heating mode, when a gas refrigerant of a high temperature and high pressure state is supplied to the internal condenser **153**, the controller **180** opens the switch

door **159** so that outdoor air, having passed through the evaporator **157** of the HVAC module **151** from the outside passes through the internal condenser **153**.

[0095] Accordingly, when outdoor air that is injected from the outside passes through the evaporator **157** in which a refrigerant is not supplied, the outdoor air is injected in a room temperature state that is not cooled, is converted to a high temperature state while passing through the internal condenser **153**, and is supplied into vehicle indoors together with a selective operation of the PTC heater **155**, thereby heating vehicle indoors.

[0096] In the present exemplary embodiment, in an air conditioning mode of the heat pump system **100**, operation of the heat pump system **100** and a method of controlling the heat pump system **100** will be described with reference to FIG. **3**.

[0097] First, in an air conditioning mode, as shown in FIG. **3**, as the cooling fan **117** operates by the controller **180**, the cooling apparatus **110** cools coolant that is injected into the radiator **115** together with outdoor air.

[0098] In this case, the cooling fan **117** operates in a maximum speed to cool coolant, having passed through the radiator **115** to the maximum.

[0099] In such a state, the cooled coolant circulates along the C.L through operation of the water pump **113** and cools the motor **111** and the electrical equipment **112** in a state that is cooled through heat exchange with a refrigerant while passing through the water-cooled condenser **130**.

[0100] In a state in which the refrigerant exchanges a heat with coolant while passing through the water-cooled condenser **130**, the refrigerant is injected into the air-cooled condenser **131** to secondly exchange a heat with outdoor air and thus a temperature of the refrigerant is lowered, and the refrigerant is efficiently condensed.

[0101] Here, the controller **180** determines a temperature of coolant through a temperature sensor that is mounted in the water-cooled condenser **130** and controls a flux of the water pump **113** or a wind amount of the cooling fan **117** according to a temperature state of a waste heat occurring in the motor **111** and the electrical equipment **112** and a temperature state of coolant.

[0102] The controller **180** opens the R.L by operating the second valve **167** so that a refrigerant of a low temperature that is cooled while passing through the air-cooled condenser **131** in the air conditioner apparatus **150** is injected into the second expansion valve **171** that is connected to the evaporator **157** of the HVAC module **151**.

[0103] The refrigerant of a low temperature that is injected into the second expansion valve **171** is supplied to the evaporator **157** along the R.L in an expanded state.

[0104] Thereafter, the refrigerant is evaporated through heat exchange with outdoor air in the evaporator **157** and is compressed while passing through the accumulator **163** and the compressor **161** along the R.L.

[0105] While the refrigerant, having compressed through the above-described operation repeats the above-described operation through opening of the R.L that is connected again to the water-cooled condenser **130** through operation of the first valve **165**, the refrigerant circulates along the R.L.

[0106] Here, outdoor air that is injected into the HVAC module **151** is cooled while passing through the evaporator **157** by the refrigerant of a low temperature state that is injected into the evaporator **157**.

[0107] In this case, the switch door **159** closes a passing portion toward the internal condenser **153** so that the cooled outdoor air does not pass through the internal condenser **153** and the PTC heater **155** and directly injects the cooled outdoor air into the vehicle, thereby performing air conditioning.

[0108] In a dehumidification mode of the heat pump system **100**, operation of the heat pump system **100** and a method of controlling the heat pump system **100** will be described with reference to FIG. **4**.

[0109] First, in the dehumidification mode, as shown in FIG. **4**, as the cooling fan **117** operates by the controller **180**, the cooling apparatus **110** cools coolant that is injected into the radiator **115** together with outdoor air.

[0110] In such a state, the cooled coolant is injected into the water-cooled condenser **130** through operation of the water pump **113**, and is circulated along the C.L in a state having a lowered temperature through heat exchange with a refrigerant, thereby cooling the motor **111** and the electrical equipment **112**.

[0111] Here, the controller **180** determines a temperature of coolant and a refrigerant through a temperature sensor that is mounted in the water-cooled condenser **130** and controls a flux the water pump **113** or a wind amount of the cooling fan **117** according to a temperature state of a waste heat that has occurred in the motor **111** and the electrical equipment **112**, a temperature state of coolant, and a pressure state of the refrigerant.

[0112] In order to inject a refrigerant of a low temperature that is cooled through heat exchange with coolant of a low temperature state and outdoor air into the second expansion valve **171** that is connected to the evaporator **157** of the HVAC module **151** while sequentially passing through the water-cooled condenser **130** and the air-cooled condenser **131**, the air conditioner apparatus **150** opens the R.L through operation of the second valve **167**.

[0113] Thereafter, the refrigerant of a low temperature that is injected into the second expansion valve **171** is supplied to the evaporator **157** along the R.L in an expanded state.

[0114] Thereafter, the refrigerant is evaporated through heat exchange with outdoor air in the evaporator **157** and is compressed to a gas refrigerant of a high temperature high pressure state while passing through the accumulator **163** and the compressor **161** along the R.L.

[0115] As the R.L that is connected to the internal condenser **153** is opened by the first valve **165**, the compressed gas refrigerant is supplied to the internal condenser **153**.

[0116] Here, the pressure sensor **175** that is mounted on the R.L between the compressor **161** and the first valve **165** measures a pressure of a refrigerant that is exhausted from the compressor **161** and outputs a measured value thereof to the controller **180**.

[0117] The controller **180** determines a pressure of the refrigerant according to the measured value that is output from the pressure sensor **175** and adjusts opening of the first valve **165** according to a requested vehicle state.

[0118] The refrigerant, having passed through the internal condenser **153** passes through the water-cooled condenser **130** along the R.L that is connected to the water-cooled condenser **130** and is injected into the air-cooled condenser **131** in a state that is expanded through the first expansion valve **169**, and circulates along the R.L while repeating the above-described operation.

[0119] In this case, the controller **180** adjusts an expansion amount of a refrigerant through adjustment of opening of the first and second expansion valves **169** and **171**.

[0120] Here, outdoor air that is injected into the HVAC module **151** is cooled while passing through the evaporator **157** by the refrigerant of a low temperature state that is injected into the evaporator **157**.

[0121] In this case, the switch door **159** opens a portion that is connected to the internal condenser **153** so that the cooled outdoor air passes through the internal condenser **153**, and the injected outdoor air is dehumidified while passing through the evaporator **157**, is heated through the internal condenser **153**, and is injected into the vehicle, thereby dehumidifying indoors of the vehicle.

[0122] When describing a method of controlling a heat pump system for a vehicle according to an exemplary embodiment of the present invention, in the heating mode, the PTC heater **155** operates together with outdoor air, but the present invention is not limited thereto and operation of the PTC heater **155** is selected and embodied by setting of a heating temperature according to a user's selection.

[0123] Accordingly, a heating mode may includes a quick heating mode that operates together with the PTC heater **155** or a general heating mode that performs heating with only outdoor air, having passed through the internal condenser **153** without operation of the PTC heater **155**.

[0124] Therefore, as described above, when the vehicle heat pump system **100** and a method of controlling the same according to an exemplary embodiment of the present invention is applied, the vehicle heat pump system **100** includes the water-cooled condenser **130** using coolant as a heat exchange medium and the air-cooled condenser **131** using an air heat source, makes a refrigerant to flow in series and uses a waste heat source occurring in the motor **111** and the electrical equipment **112** and a heat source of outdoor air, thereby improving an entire heating performance, efficiency, and a dehumidification performance and preventing external frost of the air-cooled condenser **131** that is disposed at the outside in an ultra low temperature.

[0125] Further, as a user operates a heating mode by using a waste heat without operation of the PTC heater **155** or by using together a waste heat and the PTC heater **155** according to a peripheral environment of the vehicle, a power use amount is prevented from increasing, and by simultaneously reducing a heating load, there is a merit that an entire travel distance of the vehicle increases with the same power and an entire market value of the heat pump system can be improved.

[0126] In an air conditioning mode of the vehicle, in a low driving condition, an electric heat amount of the motor **111** and the electrical equipment **112** is small, but in IDLE and low speed driving conditions, which is a condition having a large air conditioner electric heat amount, a temperature of coolant that is injected into the water-cooled condenser is lowered, and by increasing a refrigerant condensation amount through simultaneous application of the water-cooled condenser **130** and the air-cooled condenser **131**, an air conditioning performance can be improved.

[0127] In a dehumidification mode, by reducing a frequent valve switch operation through application of a 3-way valve, occurrence of noise and a vibration due to a valve switch operation can be reduced, and in intermediate temperature and much moisture conditions, because a dehumidification mode can be continuously used, the remaining amount of condensation water according to decrease of indoor humidity is reduced and thus a condition in which moisture occurs can be reduced.

[0128] Further, by using together outdoor air and coolant as a heat exchange medium of the condensers **130** and **131**, while a structure of each constituent element is simplified, the motor **111** and the electrical equipment **112** can be cooled with one radiator **115**, and entire system package can be reduced and efficiency of the radiator can be improved through reduction of ventilation resistance.

[0129] Further, in the water-cooled condenser **130**, by performing heat exchange of coolant and a refrigerant using a waste heat that has occurred in the motor **111** and the electrical equipment **112**, a heat exchange performance can be previously prevented from being deteriorated according to external frost that has occurred when individually applying a conventional air-cooled condenser in an ultra low temperature condition, and external frost of the air-cooled condenser **131** can be prevented without a separate defrost mode.

[0130] When describing a heat pump system for a vehicle and a method of controlling the same according to an exemplary embodiment of the present invention, the vehicle heat pump system includes the first and second valves **165** and **167**, but the present invention is not limited thereto and by applying a separate 2-way valve on a cooling line and a refrigerant line, a working fluid may be bypassed or a flux of a working fluid may be adjusted.

[0131] FIG. **5** is a block diagram illustrating a heat pump system for a vehicle according to a second exemplary embodiment of the present invention.

[0132] Referring to FIG. **5**, a vehicle heat pump system **200** according to a second exemplary embodiment of the present invention includes a cooling apparatus **210** that supplies and circulates coolant to a motor **211**, an electrical equipment **212**, and a non-illustrated engine through a C.L in which coolant flows and an air conditioner apparatus **250** that is connected through an R.L in which coolant flows to adjust heating and air conditioning of vehicle indoors.

[0133] In the present exemplary embodiment, the cooling apparatus **210** includes a radiator **215** that is provided at the front of the vehicle to circulate coolant along the C.L through operation of a water pump **213** and that cools the supplied coolant through heat exchange with outdoor air and a cooling fan **217** that is mounted at the rear of the radiator **215** to ventilate wind to the radiator **215**.

[0134] The heat pump system **200** according to a second exemplary embodiment of the present invention further includes a water-cooled condenser **230** to which the C.L and the R.L are each connected and an air-cooled condenser **231** that is connected to the water-cooled condenser **230** through the R.L.

[0135] First, the water-cooled condenser **230** is connected to the C.L to change a temperature of coolant using a waste heat occurring in the motor **211** and the electrical equipment **212** according each mode of the vehicle, and the water-cooled condenser **230** is connected to the R.L to enable an injected refrigerant to exchange a heat with coolant at the inside thereof.

[0136] Here, the water-cooled condenser **230** has a temperature sensor at the inside thereof, and the temperature sensor senses a water temperature of injected coolant and a temperature of a refrigerant.

[0137] In a second exemplary embodiment of the present invention, the air-cooled condenser **231** is coupled in series to the water-cooled condenser **230** through the R.L, and the air-cooled condenser **231** is disposed at the front of the radia-

tor **215** to enable a refrigerant that is injected into the inside thereof coolant to exchange a heat with outdoor air.

[0138] Here, the cooling apparatus **210** according to a second exemplary embodiment of the present invention further includes a branch line **223** and a third valve **221**.

[0139] First, the branch line **223** is installed on the C.L between the water pump **213** and the radiator **215** and bypasses the C.L in order to directly supply coolant that is supplied from the water pump **213** to the water-cooled condenser **130** according to a heating mode, an air conditioning mode, and a dehumidification mode of the vehicle.

[0140] The third valve **221** selectively connects the C.L and the branch line **223**.

[0141] The third valve **221** is controlled by a controller **280**, bypasses coolant through the branch line **223** without passing through the radiator **215** through a switch operation in a heating mode of the vehicle, directly supplies the coolant to the water-cooled condenser **230**, and enables the coolant to pass through the motor **211** and the electrical equipment **212**, thereby performing a function of raising a water temperature of the coolant by a waste heat.

[0142] In order to supply coolant to the radiator **215** or the water-cooled condenser **230**, the third valve **221** is preferably a 3-way valve that selectively switches and connects the C.L and the branch line **223**.

[0143] In a second exemplary embodiment of the present invention, the air conditioner apparatus **250** includes a heating, ventilation, and air conditioning (HVAC) module **251**, a compressor **261**, an accumulator **263**, first and second valves **265** and **267**, and first and second expansion valves **269** and **271**.

[0144] The HVAC module **251** has a switch door **259** that selectively adjusts opening at the inside thereof in order to inject outdoor air, having passed through an evaporator **257** into an internal condenser **253** and a PTC heater **255** according to air conditioning, heating, and dehumidification modes.

[0145] The cooling apparatus **210** and the air conditioner apparatus **250** are connected to the controller **280** and each operate according to a control signal of the controller **280**.

[0146] The air conditioner apparatus **250** having such a configuration is the same as that in the first exemplary embodiment of the present invention and therefore a detailed description thereof will be omitted.

[0147] Further, in a method of controlling a heat pump system according to a second exemplary embodiment of the present invention, in a heating mode, by circulating coolant to the motor **211**, the electrical equipment **212**, and the water-cooled condenser **230** along the C.L instead of injecting coolant into the radiator **215** through switch of the third valve **221**, a temperature of coolant is more quickly rises through a heat exchange with a waste heat.

[0148] In a method of controlling a heat pump system according to a second exemplary embodiment of the present invention, in a heating mode in which the third valve **221** operates, only a coolant circulation path of the cooling apparatus **210** is changed and the method according to the second exemplary embodiment is the same as that of the first exemplary embodiment in operation and control of each constituent in an air conditioning mode and a dehumidification mode and thus a detailed description thereof will be omitted.

[0149] FIG. **6** is a block diagram illustrating a heat pump system for a vehicle according to a third exemplary embodiment of the present invention.

[0150] Referring to FIG. **6**, a vehicle heat pump system **300** according to a third exemplary embodiment of the present invention includes a cooling apparatus **310** that supplies and circulates coolant to a motor **311**, an electrical equipment **312** and a non-illustrated engine through a C.L in which coolant flows and an air conditioner apparatus **350** that is connected through an R.L in which a refrigerant flows to adjust heating and air conditioning of vehicle indoors.

[0151] In the present exemplary embodiment, the cooling apparatus **310** includes a radiator **315** that is provided at the front of the vehicle to circulate coolant along the C.L through operation of the water pump **313** and that cools the supplied coolant through heat exchange with outdoor air, and a cooling fan **317** that is mounted at the rear side of the radiator **315** to ventilate wind to the radiator **315**.

[0152] The heat pump system **300** according to a second exemplary embodiment of the present invention further includes a water-cooled condenser **330** in which the C.L and the R.L are each connected and an air-cooled condenser **331** that is connected to the water-cooled condenser **330** through the R.L.

[0153] First, the water-cooled condenser **330** is connected to the C.L to change a temperature of coolant using a waste heat that has occurred in the motor **311** and the electrical equipment **312** according to each mode of the vehicle, and the water-cooled condenser **330** is connected to the R.L to enable an injected refrigerant to exchange a heat with coolant at the inside thereof.

[0154] Here, the water-cooled condenser **330** has a temperature sensor at the inside thereof, and the temperature sensor senses a water temperature of the injected coolant and a temperature of a refrigerant.

[0155] In a second exemplary embodiment of the present invention, the air-cooled condenser **331** is coupled in series to the water-cooled condenser **330** through the R.L and is disposed at the front of the radiator **315** to enable a refrigerant that is injected into the inside thereof to exchange a heat with outdoor air.

[0156] Here, the air-cooled condenser **331** has a plurality of switch films **321** that selectively inject traveling wind or outdoor air from the outside of the vehicle at the front thereof.

[0157] The each switch film **321** adjusts injection of outdoor air by opening or closing a front surface of the air-cooled condenser **331** according to a heating mode, an air conditioning mode, and a dehumidification mode of the vehicle according to a driver's selection, thereby adjusting a cooling performance of the air-cooled condenser **331**.

[0158] That is, the switch film **321** operates by a control signal of a controller **380**, is closed in a heating mode, and is opened in an air conditioning mode and a dehumidification mode.

[0159] In a third exemplary embodiment of the present invention, the air conditioner apparatus **350** includes a heating, ventilation, and air conditioning (HVAC) module **351**, a compressor **361**, an accumulator **363**, first and second valves **365** and **367**, and first and second expansion valves **369** and **371**.

[0160] The HVAC module **351** has a switch door **359** that selectively adjusts opening to inject outdoor air, having passed through an evaporator **357** into an internal condenser **353** and a PTC heater **355** at the inside thereof according to air conditioning, heating, and dehumidification modes.

[0161] The cooling apparatus **310** and the air conditioner apparatus **350** are connected to the controller **380** and each operate according to a control signal of the controller **380**.

[0162] The air conditioner apparatus **350** having such a configuration is the same as that in the first exemplary embodiment of the present invention and therefore a detailed description thereof will be omitted.

[0163] Further, in a method of controlling a heat pump system according to a third exemplary embodiment of the present invention, in a heating mode, the switch film **321** that is mounted at the front of the air-cooled condenser **331** is closed by a control signal of the controller **380** to prevent traveling wind from being injected into the radiator **315** and the air-cooled condenser **331**.

[0164] Simultaneously, as the controller **380** stops operation of the cooling fan **317** or deteriorates a wind velocity thereof, cooling of coolant, having passed through the radiator **315** is prevented, and a refrigerant, having passed through the air-cooled condenser **331** exchanges a heat with outdoor air within an engine compartment, thereby using an air heat source.

[0165] Alternatively, in an air conditioning mode and a dehumidification mode, in order to inject traveling wind and outdoor air into the radiator **315** and the air-cooled condenser **331**, the each switch film **321** is opened by a control signal of the controller **380**, thereby increasing cooling efficiency of the radiator **315** and the air-cooled condenser **331**.

[0166] Here, in a dehumidification mode, the switch film **321** may maintain or close an opened state according to an air conditioner pressure.

[0167] In a method of controlling a heat pump system according to a third exemplary embodiment of the present invention, only an open or close operation of the switch film **321** that is installed at the front of the air-cooled condenser **331** is different, and the method of the third exemplary embodiment is the same as operation and control of constituent elements in a heating mode, an air conditioning mode, and a dehumidification mode according to the first exemplary embodiment and thus a detailed description thereof will be omitted.

[0168] In the first, second, and third exemplary embodiments of the present invention, in the heat pump systems **100**, **200**, and **300**, the motors **111**, **211**, and **311** and the electrical equipments **112**, **212**, and **312** are disposed in series to the water-cooled condenser **130**, **230**, and **330** in the cooling apparatus **110**, **210**, and **310**, but the present invention is not limited thereto, the water-cooled condenser **130**, **230**, and **330** may be disposed in parallel to the motor **111**, **211**, and **311** and the electrical equipments **112**, **212**, and **312**.

[0169] For convenience in explanation and accurate definition in the appended claims, the terms "upper", "lower", "inner" and "outer" are used to describe features of the exemplary embodiments with reference to the positions of such features as displayed in the figures.

[0170] The foregoing descriptions of specific exemplary embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teachings. The exemplary embodiments were chosen and described in order to explain certain principles of the invention and their practical application, to thereby enable others skilled in the art to make and utilize various exemplary embodiments of the present invention, as well as various alternatives and modifications thereof. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

1. A heat pump system for a vehicle, comprising:

a cooling apparatus that supplies and circulates coolant to a motor and an electrical equipment through a cooling line, wherein the cooling apparatus includes:

a radiator that cools the supplied coolant through heat exchange with outdoor air;

a cooling fan that ventilates wind to the radiator; and

a water pump that is connected to the cooling line and circulates the coolant along the cooling line; and

an air conditioner apparatus that is connected through a refrigerant line in order to adjust heating and air conditioning of vehicle indoors, wherein the air conditioner apparatus includes:

a water-cooled condenser that is connected to the cooling line to change a temperature of the coolant using a waste heat that has occurred in the motor and the electrical equipment according to each mode of the vehicle and that is connected to the refrigerant line to enable an injected refrigerant in the refrigerant line to exchange a heat with the coolant at the inside thereof;

an air-cooled condenser that is connected in series to the water-cooled condenser through the refrigerant line and that enables a refrigerant that is injected into the inside thereof to exchange a heat with the outdoor air; and

wherein the air-cooled condenser has a plurality of switch films that selectively inject outdoor air at the front thereof.

2. The heat pump system of claim **1**, wherein the air conditioner apparatus includes

a heating, ventilation, and air conditioning (HVAC) module having a switch door that selectively adjusts opening at the inside thereof in order to inject outdoor air having passed through an evaporator according to a heating mode, an air conditioning mode, and a dehumidification mode into an internal condenser and a positive temperature coefficient (PTC) heater;

a compressor that is connected to the evaporator through the refrigerant line and that compresses a refrigerant of a gas state;

an accumulator that is provided on the refrigerant line between the compressor and the evaporator and that supplies a gas refrigerant to the compressor;

a first valve that selectively supplies a refrigerant that is exhausted from the compressor to the water-cooled condenser or the internal condenser according to a mode of the vehicle;

a first expansion valve that receives and expands a refrigerant having passed through the internal condenser;

a second valve that enables a refrigerant that is expanded through the first expansion valve to sequentially pass through the water-cooled condenser and the air-cooled condenser and that selectively supplies the refrigerant to the evaporator or the accumulator; and

a second expansion valve that is provided between the evaporator and the second valve and that expands a refrigerant that is injected through switch of the second valve.

3. (canceled)

4. The heat pump system of claim **2**, wherein the first and second, and third valves are formed with a 3-way valve.

5. The heat pump system of claim **1**, wherein the cooling apparatus and the air conditioner apparatus are operated by a control signal of a controller.

6-8. (canceled)

9. The heat pump system of claim **1**, wherein the switch film operates by a control signal of a controller, is closed in a heating mode, and is opened in an air conditioning mode and a dehumidification mode.

10. A method of controlling a heat pump system for a vehicle having a cooling apparatus that is electrically connected to a controller and that is fluid-connected through a cooling line and that includes a radiator, a water pump, and an electrical equipment, and an air conditioner apparatus that is connected through a refrigerant line and that includes a heating, ventilation, and air conditioning (HVAC) module that is formed with a plurality of valves, an expansion valve, a compressor, an accumulator, an evaporator, an internal condenser, a positive temperature coefficient (PTC) heater, and a switch door, the method comprising:

operating the heat pump system, in a heating mode, an air conditioning mode, and a dehumidification mode according to a user's selection,

wherein the heat pump system includes a water-cooled condenser that is connected to the cooling line and the refrigerant line and an air-cooled condenser that is disposed at the front of the radiator and connected to the refrigerant line, and

changing a moving path of a refrigerant that circulates the air conditioner apparatus based on the heating mode, the air conditioning mode, and the dehumidification mode according to the user's selection, through operation of the each valve, such that a switch door of the HVAC module is selectively open and closed.

11. The method of claim **10**, wherein:

in the heating mode, by the cooling apparatus,

raising a temperature of coolant that is injected into the water-cooled condenser through a waste heat that has occurred in the motor and the electrical equipment;

enabling the coolant to exchange a heat with a refrigerant that is injected into the water-cooled condenser through the refrigerant line;

injecting the refrigerant having passed through the water-cooled condenser into the air-cooled condenser; and

enabling the refrigerant to exchange a heat with a heat source of outdoor air; and

in the heating mode, by the air conditioner apparatus,

enabling a heated refrigerant through heat exchange with coolant and outdoor air in the water-cooled condenser and the air-cooled condenser;

supplying the refrigerant to the internal condenser of the HVAC module through operation of the first valve in a state that is compressed with a gas refrigerant of a high temperature and high pressure state by passing through the accumulator and the compressor along a refrigerant line through opening of the second valve;

sequentially supplying and circulating the refrigerant having passed through the internal condenser to the water-cooled condenser and the air-cooled condenser in a state that is expanded through the first expansion valve; and

opening the switch door so that outdoor air, having passed through the evaporator of the HVAC module from the outside passes through the internal condenser; and

enabling the injected outdoor air to heat vehicle indoors together with a selective operation of the PTC heater while passing through the internal condenser.

12. The method of claim **10**, wherein in the air conditioning mode,

cooling coolant that is injected into the radiator together with outdoor air by a cooling fan; and

by the cooling apparatus:

lowering a temperature of a refrigerant by second heat exchange with outdoor air by injecting a refrigerant that has exchanged a heat with coolant while passing through the water-cooled condenser into the air-cooled condenser while cooling the electrical equipment and the motor by circulating the coolant along the cooling line in a state that is cooled through heat exchange with a refrigerant that is injected into the water-cooled condenser, and

by the air conditioner apparatus:

supplying an expanded refrigerant to the evaporator by operating the second valve so that a refrigerant of a low temperature that is cooled while passing through the air-cooled condenser injects into the second expansion valve that is connected to the evaporator of the HVAC module;

exhausting the refrigerant that is evaporated through heat exchange with outdoor air in the evaporator;

opening a refrigerant line that is connected to the water-cooled condenser through operation of the first valve and circulates the refrigerant in a state that is compressed while passing through the accumulator and the compressor; and

cooling the vehicle indoors by closing the switch door so that outdoor air that is cooled while passing through the evaporator by a refrigerant that is injected into the evaporator is not injected into the internal condenser and by directly injecting outdoor air that is cooled while passing through the evaporator into the vehicle.

13. The method of claim **12**, wherein in the air conditioning mode, when the vehicle travels, opening each switch film that is installed at a front surface of the radiator to inject traveling wind into the radiator.

14. The method of claim **10**, wherein in the dehumidification mode, as a cooling fan operates, in a state in which coolant that is injected into the radiator together with outdoor air is cooled,

by the cooling apparatus,

cooling the motor and the electrical equipment through operation of the water pump with cooled coolant while lowering a temperature of a refrigerant and coolant by heat exchange of the refrigerant and the coolant of a low temperature that is injected into the water-cooled condenser;

by the air conditioner apparatus,

opening the second valve so that a refrigerant of a low temperature that is cooled while exchanging a heat with coolant and outdoor air while sequentially passing through the water-cooled condenser and the air-cooled condenser is injected into the second expansion valve that is connected to the evaporator of the HVAC module;

supplying the expanded refrigerant to the evaporator;

supplying a refrigerant to the internal condenser by opening a refrigerant line that is connected to the internal condenser through operation of the first valve in a compressed state while passing through the accumulator and the compressor by exhausting a refrigerant that is evaporated through heat exchange with outdoor air in the evaporator;

supplying and circulating the refrigerant having passed through the internal condenser to the water-cooled condenser in a state that is expanded through the first expansion valve;

opening the switch door so that outdoor air that is cooled while passing through the evaporator of the HVAC module from the outside passes through the internal condenser; and

enabling injected outdoor air to dehumidify vehicle indoors while passing through the internal condenser and the PTC heater.

15. The method of claim **14**, wherein in the dehumidification mode, adjusting, by the controller, an expansion amount of the refrigerant through adjustment of opening of the first and second expansion valves.

16. The method of claim **14**, wherein in the dehumidification mode, when the vehicle travels, opening each switch film that is installed at a front surface of the radiator to inject traveling wind into the radiator.

17. The method of claim **10**, wherein in the heating mode, the air conditioning mode, and the dehumidification mode, controlling, by the controller, a wind amount of the cooling fan and a flux of the water pump according to a temperature state of a waste heat that has occurred in the electrical equipment and a temperature state of the coolant and the refrigerant.

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