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(54) FREQUENCY CONTROL METHOD AND SYSTEM FOR VARIABLE FREQUENCY COMPRESSOR OF HEAT PUMP HOT WATER MACHINE

(57) Disclosed are a method and a system for controlling frequency of a variable-frequency compressor in a heat pump water heater. The method includes: detecting water temperature of water flowing out from a heat exchanger and water tank temperature of a water tank; determining preset water temperature of the water flowing out from the heat exchanger according to the water tank temperature; and controlling the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature. The present method and system propose a control mode of frequency of the compressor based on the water temperature of the water flowing out from the heat exchanger. Working frequency of the variable-frequency compressor may be reduced effectively and working energy efficiency of a heat pump group may be improved under low water tank temperature. Meanwhile, in case of ensuring stable water temperature, minimum working frequency of the compressor may be controlled effectively and thus reliability of the compressor may be ensured.

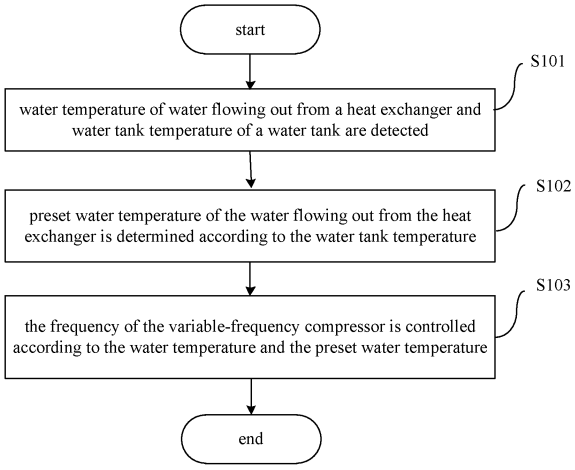

Fig. 1

EP 3 299 744 A1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and benefits of Chinese Patent Application Serial No. 201510268372.7, entitled "Method and system for controlling frequency of variable-frequency compressor in heat pump water heater", filed with the State Intellectual Property Office of P. R. China on May 22, 2015, the entire content of which is incorporated herein by reference.

FIELD

[0002] The present disclosure relates to heat pump water heater technology, and more particularly relates to a method and a system for controlling frequency of a variable-frequency compressor in a heat pump water heater.

BACKGROUND

[0003] In recent years, as an effective energy-saving and environment-friendly equipment, the heat pump water heater has been used increasingly around the world. With the development of variable-frequency technology, the variable-frequency heat pump water heater is emerging. A heating capacity and an energy efficiency of the variable-frequency heat pump water heater are higher than those of the fixed-frequency heat pump water heater, especially under low environment temperature.

[0004] At present, in the frequency control method used for the variable-frequency compressor in the heat pump water heater, a difference between target temperature of a water tank and current temperature of the water tank is regarded as a feedback, i.e., when the difference is greater than a certain value, the variable-frequency compressor is working at a high frequency as far as possible to produce more heat and shorten a heating time; and when the difference is smaller than the certain value, the frequency of the variable-frequency compressor is adjusted dynamically, and in order to ensure that temperature of the water tank is maintained within a target temperature range, the variable-frequency compressor is working at a lower frequency generally.

[0005] In general, heat produced by the variable-frequency heat pump water heater may increase with an increase of the frequency of the variable-frequency compressor thereof. However, an energy efficiency ratio of the heat pump water heater changes in shape of a parabola, which means that the energy efficiency ratio may decrease with an increase of the frequency of the variable-frequency compressor when the frequency is higher than a certain frequency, and the energy efficiency ratio may decrease with a decrease of the frequency of the variable-frequency compressor when the frequency is lower than the certain frequency. Thus, with an existing method for controlling the frequency of the variable-frequency compressor in the heat pump water heater by controlling the temperature in the water tank, the energy-saving advantage of the variable-frequency heat pump water heater cannot be exploited sufficiently and reliability of the variable-frequency compressor cannot be guaranteed. Additionally, a maximum pressure of the variable-frequency compressor may increase firstly and decrease subsequently with an increase of the frequency.

SUMMARY

[0006] Embodiments of the present disclosure seek to solve at least one of the problems existing in the related art to at least some extent.

[0007] Accordingly, a first objective of the present disclosure is to provide a method for controlling frequency of a variable-frequency compressor in a heat pump water heater. Based on water temperature of water flowing out from a heat exchanger, the method may reduce a working frequency of the variable-frequency compressor effectively and improve working energy efficiency of a heat pump group under low water tank temperature. Meanwhile, in case of ensuring the stable water temperature, minimum working frequency of the variable-frequency compressor may be controlled effectively and thus reliability of the variable-frequency compressor may be ensured.

[0008] A second objective of the present disclosure is to provide a system for controlling frequency of a variable-frequency compressor in a heat pump water heater.

[0009] In order to achieve the above objectives, the method for controlling frequency of the variable-frequency compressor in the heat pump water heater according to embodiments of a first aspect of the present disclosure includes: detecting a water temperature of water flowing out from a heat exchanger and a water tank temperature of a water tank; determining a preset water temperature of the water flowing out from the heat exchanger according to the water tank temperature; and controlling the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature.

[0010] With the method according to embodiments of the present disclosure, the water temperature of the water flowing out from the heat exchanger and the water tank temperature of the water tank are firstly detected, and then the preset water temperature of the water flowing out from the heat exchanger is determined according to the water tank temperature; and the frequency of the variable-frequency compressor is controlled according to the water temperature and the preset water temperature. The embodiments of the present disclosure provide a method for controlling the frequency of the variable-frequency compressor based on the water temperature of the water flowing out from the heat exchanger. Under low water tank temperature, working frequency of the variable-frequency compressor may be reduced effectively and working energy efficiency of the heat pump group may be improved. Meanwhile, in case of ensuring

the water temperature is constant, minimum working frequency of the variable-frequency compressor may be controlled effectively and thus reliability of the variable-frequency compressor may be ensured.

[0011] In an embodiment of the present disclosure, the preset water temperature is determined according to T1S=f(T5), where T1S is the preset water temperature and T5 is the water tank temperature.

[0012] In an embodiment of the present disclosure, T1S is computed according to T1S=a1*a2*a3*T5+b, where a1 is a first correction factor for a water-water heat exchanger in the water tank, a2 is a second correction factor for a capacity of the heat pump group, a3 is a third correction factor, and b is a temperature difference correction factor.

[0013] According to an embodiment of the present disclosure, controlling the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature includes: acquiring a temperature difference between the water temperature and the preset water temperature; determining a temperature range comprising the temperature difference, and acquiring a correction value according to the temperature range; and determining a target frequency of the variable-frequency compressor according to the frequency of the variable-frequency compressor and the correction value.

[0014] According to an embodiment of the present disclosure, the method also includes: comparing the target frequency of the variable-frequency compressor with a working frequency of the heat pump group in a set of working frequencies; and acquiring a working frequency closest to the target frequency, and determining the working frequency closest to the target frequency as the target frequency.

[0015] According to an embodiment of the present disclosure, determining the working frequency closest to the target frequency as the target frequency includes: acquiring a minimum working frequency and a maximum working frequency of the heat pump group under the water tank temperature; comparing the working frequency with the minimum working frequency and the maximum working frequency respectively; and determining the working frequency as the target frequency if the working frequency is between the minimum working frequency and the maximum working frequency.

[0016] According to an embodiment of the present disclosure, acquiring a minimum working frequency and a maximum working frequency of the heat pump group under the water tank temperature includes: determining the minimum working frequency and the maximum working frequency according to an outdoor temperature T4 and the water tank temperature T5; determining that the variable-frequency compressor is working at a frequency in a first preset frequency range and determining the minimum working frequency and the maximum working frequency according to the first preset frequency range, if the outdoor temperature T4 is smaller than or equal to a first preset temperature threshold and the water tank temperature T5 is greater than or equal to a second preset temperature threshold, or if the outdoor temperature T4 is greater than a third preset temperature threshold and the water tank temperature T5 is greater than or equal to the second preset temperature threshold, in which the first preset temperature threshold is smaller than the third preset temperature threshold; and determining that the variable-frequency compressor is working at a frequency in a second preset frequency range and determining the minimum working frequency and the maximum working frequency according to the second preset frequency range, if the outdoor temperature T4 is in a first preset temperature range and the water tank temperature T5 is in a second preset temperature range, in which the first preset frequency range is narrower than the second preset frequency range.

[0017] According to an embodiment of the present disclosure, the method also includes: determining the maximum working frequency as the target frequency if the working frequency is greater than the maximum working frequency; and determining the minimum working frequency as the target frequency if the working frequency is smaller than the minimum working frequency.

[0018] In order to achieve the above objectives, the system for controlling frequency of the variable-frequency compressor in the heat pump water heater according to embodiments of a second aspect of the present disclosure includes: the variable-frequency compressor; a heat exchanger connected to the variable-frequency compressor; a first temperature sensor disposed at a water outlet of the heat exchanger, configured to detect a water temperature of water flowing out from the heat exchanger; a water tank connected to the heat exchanger; a second temperature sensor disposed in the water tank, configured to detect a water tank temperature; and a controller, configured to acquire the water temperature from the first temperature sensor and the water tank temperature from the second temperature sensor, and to determine a preset water temperature of the water flowing out from the heat exchanger according to the water tank temperature, and to control the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature.

[0019] With the system according to embodiments of the present disclosure, the controller acquires the water temperature from the first temperature sensor and the water tank temperature from the second temperature sensor, and then determines preset water temperature according to the water tank temperature, and controls the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature. The embodiments of the present disclosure provide a method for controlling the frequency of the variable-frequency compressor based on the water temperature of the water flowing out from the heat exchanger. Working frequency of the variable-frequency compressor may be reduced effectively and working energy efficiency of a heat pump group may be improved, when tempera-

ture in a water tank is low. Meanwhile, in case of ensuring the water temperature is constant, minimum working frequency of the variable-frequency compressor may be controlled effectively and thus reliability of the variable-frequency compressor may be ensured.

[0020] In an embodiment of the present disclosure, the controller determines the preset water temperature according to T1S=f(T5), where T1S is the preset water temperature and T5 is the water tank temperature.

[0021] In an embodiment of the present disclosure, T1S is computed according to T1S=a1*a2*a3*T5+b, where a1 is a first correction factor for a water-water heat exchanger in the water tank, a2 is a second correction factor for a capacity of a heat pump group, a3 is a third correction factor, and b is a temperature difference correction factor.

[0022] According to an embodiment of the present disclosure, the controller is configured to acquire a temperature difference between the water temperature and the preset water temperature; to determine a temperature range comprising the temperature difference, and acquire a correction value according to the temperature range; and to determine a target frequency of the variable-frequency compressor according to the frequency of the variable-frequency compressor and the correction value.

[0023] According to an embodiment of the present disclosure, the controller is also configured to compare the target frequency of the variable-frequency compressor with a working frequency of the heat pump group in a set of working frequencies; and to acquire a working frequency closest to the target frequency, and determine the working frequency closest to the target frequency as the target frequency.

[0024] According to an embodiment of the present disclosure, the controller is also configured to acquire a minimum working frequency and a maximum working frequency of the heat pump group under the water tank temperature; to compare the working frequency with the minimum working frequency and the maximum working frequency respectively; and to determine the working frequency as the target frequency if the working frequency is between the minimum working frequency and the maximum working frequency.

[0025] According to an embodiment of the present disclosure, the controller is also configured to determine the minimum working frequency and the maximum working frequency according to an outdoor temperature T4 and the water tank temperature T5; to determine the minimum working frequency and the maximum working frequency according to a first preset frequency range, if the outdoor temperature T4 is smaller than or equal to a first preset temperature threshold and the water tank temperature T5 is greater than or equal to a second preset temperature threshold or if the outdoor temperature T4 is greater than a third preset temperature threshold and the water tank temperature T5 is greater than or equal to the second preset temperature threshold, such that the variable-frequency compressor is working at the frequency in the first preset frequency range, in which the first preset temperature threshold is smaller than the third preset temperature threshold; and to determine the minimum working frequency and the maximum working frequency according to a second preset frequency range, if the outdoor temperature T4 is in a first preset temperature range and the water tank temperature T5 is in a second preset temperature range such that the variable-frequency compressor is working at the frequency in the second preset frequency range, in which the first preset frequency range is narrower than the second preset frequency range.

[0026] According to an embodiment of the present disclosure, the controller is also configured to determine the maximum working frequency as the target frequency if the working frequency is greater than the maximum working frequency; and to determine the minimum working frequency as the target frequency if the working frequency is smaller than the minimum working frequency.

[0027] Additional aspects and advantages of embodiments of present disclosure will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] These and other aspects and advantages of embodiments of the present disclosure will become apparent and more readily appreciated from the following descriptions made with reference to the drawings, in which:

Fig. 1 is a flow chart of a method for controlling frequency of a variable-frequency compressor in a heat pump water heater according to an embodiment of the present disclosure;

Fig. 2 is a schematic diagram of a system for controlling frequency of a variable-frequency compressor in a heat pump water heater according to an embodiment of the present disclosure;

Fig. 3 is a schematic diagram of a system for controlling frequency of a variable-frequency compressor in a heat pump water heater according to an embodiment of the present disclosure.

Reference numerals:

[0029]

variable-frequency compressor 10, heat exchanger 20, first temperature sensor 30, water tank 40, second temperature sensor 50, controller 60, throttle 70, circulating water pump 80, water-water heat exchanger 90 in the water tank and water-refrigerant heat exchanger 21.

DETAILED DESCRIPTION

[0030] Reference will be made in detail to embodiments of the present disclosure, where the same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions. The embodiments described herein with reference to drawings are explanatory, and used to generally understand the present disclosure. The embodiments shall not be construed to limit the present disclosure.

[0031] A method and a system for controlling frequency of a variable-frequency compressor in a heat pump water heater according to embodiments of the present disclosure will be further described with reference to drawings.

[0032] Fig. 1 is a flow chart of the method for controlling frequency of the variable-frequency compressor in the heat pump water heater according to an embodiment of the present disclosure.

[0033] As shown in Fig. 1, the method for controlling frequency of the variable-frequency compressor in the heat pump water heater may include following acts.

[0034] In act S101, water temperature of water flowing out from a heat exchanger and water tank temperature of a water tank are detected.

[0035] Specifically, when the variable-frequency heat pump water heater is working, a first temperature sensor disposed at a water outlet of the heat exchanger may detect the water temperature of the water flowing out from the heat exchanger, and a second temperature sensor disposed in the water tank may detect the water tank temperature.

[0036] In act S102, preset water temperature of the water flowing out from the heat exchanger is determined according to the water tank temperature.

[0037] After the water tank temperature is acquired, the preset water temperature T1S may be determined according to:

$$T1S=f(T5)$$

where T5 is the water tank temperature.

[0038] For example, T1S=a1*a2*a3*T5+b, where a1 is a first correction factor for a water-water heat exchanger in the water tank, a2 is a second correction factor for a capacity of a heat pump group, a3 is a third correction factor, and b is a temperature difference correction factor.

[0039] It should be noted that the first correction factor for the water-water heat exchanger in the water tank, the second correction factor for a capacity of a heat pump group, the third correction factor and the temperature difference correction factor may be set according to a practical operating condition, which means that different values may be assigned to each of the water-water heat exchanger in the water tank, the second correction factor for a capacity of a heat pump group, the third correction factor and the temperature difference correction factor in different operating conditions.

[0040] In act S103, the frequency of the variable-frequency compressor is controlled according to the water temperature and the preset water temperature.

[0041] In an embodiment of the present disclosure, after the preset water temperature of the water flowing out from the heat exchanger is determined according to the water tank temperature, a temperature difference between the water temperature and the preset water temperature may be acquired firstly, and then a temperature range including the temperature difference may be determined, and a correction value may be acquired according to the temperature range, and a target frequency of the variable-frequency compressor may be determined according to the current frequency of the variable-frequency compressor and the correction value.

[0042] A corresponding relationship between the temperature range including the temperature difference and the correction value for the frequency of the variable-frequency compressor may be pre-stored in a frequency controlling system of the variable-frequency compressor, and the temperature difference is a result obtained by subtracting the preset water temperature from the water temperature.

[0043] For example, a table of the pre-stored corresponding relationship between the temperature range and the correction value is shown in Table. 1.

Table. 1 Table of the corresponding relationship

temperature range (°C)	correction value (Hz)
(2,3]	-8Hz
(1,2]	-4Hz
[-1,1]	0Hz
(-1,-2]	4Hz
(-2,-3]	8Hz

[0044] It should be noted that Table. 1 only shows an example or a part of the corresponding relationship.

[0045] For example, assume that the corresponding relationship is shown in Table. 1, the preset water temperature measured by a thermometer in the water tank is 14°C, the water temperature of the water flowing out from the heat exchanger acquired by the second temperature sensor is 15.6°C, and the current frequency of the variable-frequency compressor is 18Hz, then the temperature difference between the water temperature and the preset water temperature is computed as 1.6°C which falls into the temperature range (1,2] according to Table. 1, and the temperature range (1,2] corresponds the correction value -4Hz. Thus, the target frequency of the variable-frequency compressor is acquired by adding the correction value to the current frequency of the var-

iable-frequency compressor, i.e., the target frequency is 12Hz.

[0046] Additionally, in this embodiment, after the target frequency is determined according to the current frequency of the variable-frequency compressor and the correction value, the target frequency can also be adjusted according to a working frequency of the heat pump group.

[0047] Specifically, the working frequency closest to the target frequency may be acquired by comparing the target frequency with the working frequency of the heat pump group in a set of working frequencies.

[0048] Generally, the heat pump group works at different frequencies belong to different working frequency ranges under different water tank temperatures. After the working frequency closest to the target frequency is acquired, a minimum working frequency and a maximum working frequency of the heat pump group may be acquired firstly under the current water tank temperature, and the working frequency may be compared with the minimum working frequency and the maximum working frequency respectively. The working frequency may be determined as the target frequency if the working frequency is between the minimum working frequency and the maximum working frequency, and the maximum working frequency may be determined as the target frequency if the working frequency is greater than the maximum working frequency, and the minimum working frequency may be determined as the target frequency if the working frequency is smaller than the minimum working frequency.

[0049] In an embodiment of the present disclosure, the minimum working frequency and the maximum working frequency may be determined according to outdoor temperature T4 and the water tank temperature T5. Specifically, a working frequency range of the variable-frequency compressor relates to the outdoor temperature T4 and the water tank temperature T5. Specifically, if the outdoor temperature T4 is smaller than or equal to a first preset temperature threshold and the water tank temperature T5 is greater than or equal to a second preset temperature threshold, or if the outdoor temperature T4 is greater than a third preset temperature threshold and the water tank temperature T5 is greater than or equal to the second preset temperature threshold, the variable-frequency compressor is working at a frequency in a first preset frequency range, the minimum working frequency and the maximum working frequency may be determined according to the first preset frequency range; and if the outdoor temperature T4 is in a first preset temperature range and the water tank temperature T5 is in a second preset temperature range, the variable-frequency compressor is working at a frequency in a second preset frequency range, the minimum working frequency and the maximum working frequency may be determined according to the second preset frequency range.

[0050] It should be noted that the first preset temperature threshold is smaller than the third preset temperature threshold and the first preset frequency range is narrower than the second preset frequency range.

[0051] For example, assume that the first temperature threshold is -5°C, the second temperature threshold is 50°C, the third temperature threshold is 30°C, the second temperature threshold is 50°C, the first temperature range is 5°C-20°C and the second temperature range is 20°C-40°C. If the outdoor temperature T4 is smaller than or equal to -5°C and the water tank temperature T5 is greater than or equal to 50°C, or if the outdoor temperature T4 is greater than 30°C and the water tank temperature T5 is greater than or equal to 50°C, the variable-frequency compressor is working at a frequency in a range of 42-60Hz, and the minimum working frequency may be determined as 42Hz and the maximum working frequency may be determined as 60Hz; and if the outdoor temperature T4 is in 5°C-20°C and the water tank temperature T5 is in 20°C -40°C, the variable-frequency compressor is working at a frequency in a range of 10-92Hz, and the minimum working frequency may be determined as 10Hz and the maximum working frequency may be determined as 92Hz. For example, assume that the target frequency Fs of the variable-frequency compressor computed according to the water temperature and the preset water temperature is 15Hz, the set of working frequencies of the heat pump group includes a first working frequency F1 equal to 10Hz, a second working frequency F2 equal to 14Hz, a third working frequency F3 equal to 18Hz and a fourth working frequency F4 equal to 22Hz. If the maximum working frequency F_{max} of the heat pump group under the current water tank temperature is 17Hz and the minimum working frequency F_{min} of the heat pump group under the current water tank temperature is 11Hz, after the target frequency Fs is acquired, the working frequency closest to the target frequency Fs is the second working frequency F2 by comparing the target frequency Fs with each of the set of working frequencies, and because 14Hz is between 11Hz and 17Hz, the second working frequency F2 is determined as the target frequency, such that the variable-frequency compressor works at 14Hz.

[0052] Thus, by using the water temperature of the water flowing out from the heat exchanger to control the frequency of the variable-frequency compressor, the working frequency of the variable-frequency compressor may be reduced and the working energy efficiency of the heat pump group may be improved effectively. The minimum frequency of the heat pump group may be limited when the water temperature is high, such that the reliability of the variable-frequency compressor may be guaranteed.

[0053] With the method according to embodiments of the present disclosure, the water temperature of the water flowing out from the heat exchanger and the water tank temperature of the water tank are firstly detected, and then the preset water temperature of the water flowing out from the heat exchanger is determined according to the water tank temperature; and the frequency of the

variable-frequency compressor is controlled according to the water temperature and the preset water temperature. The embodiments of the present disclosure provide a method for controlling the frequency of the variable-frequency compressor based on the water temperature of the water flowing out from the heat exchanger. When temperature in a water tank is low, working frequency of the variable-frequency compressor may be reduced effectively, such that working energy efficiency of a heat pump group may be improved. Meanwhile, in case of ensuring constant water temperature, working minimum frequency of the variable-frequency compressor may be controlled effectively and thus reliability of the variable-frequency compressor may be guaranteed.

[0054] In order to achieve the above objectives, embodiments of the present disclosure also provide a system for evaluating consumption condition of a magnesium rod in a water heater.

[0055] Fig. 2 is a schematic diagram of a system for controlling frequency of a variable-frequency compressor in a heat pump water heater according to an embodiment of the present disclosure.

[0056] As shown in Fig. 2, the system for controlling the frequency of the variable-frequency compressor in the heat pump water heater includes the variable-frequency compressor 10, a heat exchanger 20 connected to the variable-frequency compressor 10, a first temperature sensor 30 disposed at a water outlet of the heat exchanger 20, a water tank 40 connected to the heat exchanger 20, a second temperature sensor 50 disposed in the water tank 40 and a controller 60.

[0057] The first temperature sensor 30 is configured to detect water temperature of water flowing out from the heat exchanger 20; the second temperature sensor 50 is configured to detect water tank temperature of the water tank 40; and the controller is configured to acquire the water temperature of the water flowing out from the heat exchanger 20 from the first temperature sensor 30 and the water tank temperature of the water tank 40 from the second temperature sensor 50, and to determine preset water temperature of the water flowing out from the heat exchanger 20 according to the water tank temperature, and to control the frequency of the variable-frequency compressor 10 according to the water temperature and the preset water temperature of the water flowing out from the heat exchanger 20.

[0058] The controller 60 may determine the preset water temperature T1S according to:

$$T1S=f(T5),$$

in which T5 is the water tank temperature.

[0059] For example, T1S=a1*a2*a3*T5+b, in which a1 is a first correction factor for a water-water heat exchanger in the water tank, a2 is a second correction factor for a capacity of a heat pump group, a3 is a third correction factor, and b is a temperature difference correction factor.

[0060] It should be noted that the first correction factor for the water-water heat exchanger in the water tank, the second correction factor for a capacity of a heat pump group, the third correction factor and the temperature difference correction factor may be set according to a practical operating condition, which means that each of the water-water heat exchanger in the water tank, the second correction factor for a capacity of a heat pump group, the third correction factor and the temperature difference correction factor may be have different values in different operating conditions.

[0061] After the controller 60 determines the preset water temperature of the water flowing out from the heat exchanger 20 according to the water tank temperature, the controller 60 may acquire a temperature difference between the water temperature of the water flowing out from the heat exchanger 20 and the preset water temperature firstly, determine a temperature range including the temperature difference and acquire a correction value according to the temperature range, and determine a target frequency of the variable-frequency compressor 10 according to the current frequency of the variable-frequency compressor 10 and the correction value.

[0062] For example, a table of the pre-stored corresponding relationship between the temperature range and the correction value is shown in Table. 1.

Table. 1 Table of the corresponding relationship

temperature range (°C)	correction value (Hz)
(2,3]	-8Hz
(1,2]	-4Hz
[-1,1]	0Hz
(-1,-2]	4Hz
(-2,-3]	8Hz

[0063] It should be noted that Table. 1 only shows an example or a part of the corresponding relationship.

[0064] For example, assume that the corresponding relationship is shown in Table. 1, the preset water temperature of the water flowing out from the heat exchanger 20 computed according to the water tank temporary is 14°C, the water temperature of the water flowing out from the heat exchanger acquired by the second temperature sensor 50 is 15.6°C, and the current frequency of the variable-frequency compressor 10 is 18Hz. The temperature difference between the water temperature and the preset water temperature is computed as 1.6°C which falls into the temperature range (1,2] according to Table. 1, and the temperature range (1,2] corresponds the correction value -4Hz. Thus, the target frequency of the variable-frequency compressor is acquired by adding the correction value to the current frequency of the variable-frequency compressor, i.e., the target frequency is 12Hz.

[0065] Additionally, in this embodiment, after the controller 60 determines the target frequency of the variable-frequency compressor 10 according to the current frequency of the variable-frequency compressor 10 and the correction value, the controller 60 may also adjust the target frequency according to a working frequency of the heat pump group.

[0066] Specifically, the controller 60 may acquire the working frequency closest to the target frequency of the variable-frequency compressor 10 by comparing the target frequency with a working frequency of the heat pump group in a set of working frequencies.

[0067] Generally, working frequency ranges of the heat pump group are different in different water tank temperatures. After the controller 60 acquires the working frequency closest to the target frequency, a minimum working frequency and a maximum working frequency of the heat pump group may be acquired firstly under the current water tank temperature, and the working frequency closest to the target frequency may be compared with the minimum working frequency and the maximum working frequency respectively. The working frequency closest to the target frequency may be determined as the target frequency if the working frequency closest to the target frequency is between the minimum working frequency and the maximum working frequency, and the maximum working frequency may be determined as the target frequency if the working frequency closest to the target frequency is greater than the maximum working frequency, and the minimum working frequency may be determined as the target frequency if the working frequency closest to the target frequency is smaller than the minimum working frequency.

[0068] In an embodiment of the present disclosure, the controller 60 may determine the minimum working frequency and the maximum working frequency according to outdoor temperature T4 and the water tank temperature T5. Specifically, a working frequency range of the variable-frequency compressor relates to the outdoor temperature T4 and the water tank temperature T5. Specifically, if the outdoor temperature T4 is smaller than or equal to a first preset temperature threshold and the water tank temperature T5 is greater than or equal to a second preset temperature threshold, or if the outdoor temperature T4 is greater than a third preset temperature threshold and the water tank temperature T5 is greater than or equal to the second preset temperature threshold, the variable-frequency compressor is working at a frequency in a first preset frequency range, and the minimum working frequency and the maximum working frequency may be determined according to the first preset frequency range; and if the outdoor temperature T4 is in a first preset temperature range and the water tank temperature T5 is in a second preset temperature range, the variable-frequency compressor is working at a frequency in a second preset frequency range, and the minimum working frequency and the maximum working frequency may be determined according to the second preset frequency range.

[0069] It should be noted that the first preset temperature threshold is smaller than the third preset temperature threshold and the first preset frequency range is narrower than the second preset frequency range.

[0070] For example, assume that the first temperature threshold is -5°C, the second temperature threshold is 50°C, the third temperature threshold is 30°C, the first temperature range is 5°C-20°C and the second temperature range is 20°C-40°C. If the outdoor temperature T4 is smaller than or equal to -5°C and the water tank temperature T5 is greater than or equal to 50°C, or if the outdoor temperature T4 is greater than 30°C and the water tank temperature T5 is greater than or equal to 50°C, the working frequency range of the variable-frequency compressor is 42-60Hz and then the control 60 may determine the minimum working frequency as 42Hz and the maximum working frequency as 60Hz; and if the outdoor temperature T4 is in 5°C-20°C, the water tank temperature T5 is in 20°C-40°C, the working frequency range of the variable-frequency compressor is 10-92Hz and then the controller 60 may determine that the minimum working frequency is 10Hz and the maximum working frequency is 92Hz.

[0071] For example, assume that the target frequency Fs of the variable-frequency compressor 10 computed according to the water temperature and the preset water temperature is 15Hz, the set of working frequencies of the heat pump group includes a first working frequency F1 equal to 10Hz, a second working frequency F2 equal to 14Hz, a third working frequency F3 equal to 18Hz and a fourth working frequency F4 equal to 22Hz. If the maximum working frequency F_{max} of the heat pump group under the current water tank temperature is 17Hz and the minimum working frequency F_{min} of the heat pump group under the current water tank temperature is 11Hz, after the target frequency Fs is acquired, it may be determined that the working frequency closest to the target frequency Fs is the second working frequency F2 by comparing the target frequency Fs with each of the set of working frequencies, and because 14Hz is between 11Hz and 17Hz, the controller 60 may determine that the second working frequency F2 is the target frequency of the variable-frequency compressor 10 and enables the variable-frequency compressor 10 to work at 14Hz.

[0072] Fig. 3 illustrates a schematic diagram of a system for controlling frequency of a variable-frequency compressor in a heat pump water heater. The heat exchanger 20 between variable-frequency compressor 10 and the throttle 70 may be a water- refrigerant heat exchanger or an air-refrigerant heat exchanger. The water tank 40 includes a second temperature sensor 50 and a water-water heat exchanger 90, and the water-water heat exchanger 90 in the water tank is connected to the water-refrigerant heat exchanger 21 via a circulating water pump 80.

[0073] With the system according to embodiments of the present disclosure, the controller acquires the water

temperature from the first temperature sensor and the water tank temperature from the second temperature sensor, and then determines preset water temperature according to the water tank temperature, and controls the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature. The embodiments of the present disclosure provide a method for controlling the frequency of the variable-frequency compressor based on the water temperature of the water flowing out from the heat exchanger. When temperature in a water tank is low, working frequency of the variable-frequency compressor may be reduced effectively, such that working energy efficiency may be improved. Meanwhile, in case of ensuring the water temperature is constant, working minimum frequency of the variable-frequency compressor may be controlled effectively and thus reliability of the variable-frequency compressor may be ensured.

[0074] In the description of embodiments of the present disclosure, reference throughout this specification to "one embodiment", "some embodiments," "an embodiment" , "a specific example," or "some examples," means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. In this specification, the appearances of the phrases in various places throughout this specification are not necessarily referring to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples. In addition, in a case without contradictions, different embodiments or examples or features of different embodiments or examples may be combined by those skilled in the art.

[0075] Those skilled in the art shall understand that terms such as "first" and "second" are used herein for purposes of description and are not intended to indicate or imply relative importance or significance. Thus, the feature defined with "first" and "second" may comprise one or more this feature. In the description of the present disclosure, "a plurality of" means two or more than two, unless specified otherwise.

[0076] It will be understood that, the flow chart or any process or method described herein in other manners may represent a module, segment, or portion of code that comprises one or more executable instructions to implement the specified logic function(s) or that comprises one or more executable instructions of the steps of the progress. And the scope of a preferred embodiment of the present disclosure includes other implementations in which the order of execution may differ from that which is depicted in the flow chart, which should be understood by those skilled in the art.

[0077] The logic and/or step described in other manners herein or shown in the flow chart, for example, a particular sequence table of executable instructions for realizing the logical function, may be specifically achieved in any computer readable medium to be used by the instruction execution system, device or equipment (such as the system based on computers, the system comprising processors or other systems capable of obtaining the instruction from the instruction execution system, device and equipment and executing the instruction), or to be used in combination with the instruction execution system, device and equipment. As to the specification, "the computer readable medium" may be any device adaptive for including, storing, communicating, propagating or transferring programs to be used by or in combination with the instruction execution system, device or equipment. More specific examples of the computer readable medium comprise but are not limited to: an electronic connection (an electronic device) with one or more wires, a portable computer enclosure (a magnetic device), a random access memory (RAM), a read only memory (ROM), an erasable programmable read-only memory (EPROM or a flash memory), an optical fiber device and a portable compact disk read-only memory (CDROM). In addition, the computer readable medium may even be a paper or other appropriate medium capable of printing programs thereon, this is because, for example, the paper or other appropriate medium may be optically scanned and then edited, decrypted or processed with other appropriate methods when necessary to obtain the programs in an electric manner, and then the programs may be stored in the computer memories.

[0078] It should be understood that the various parts of the present disclosure may be realized by hardware, software, firmware or combinations thereof. In the above embodiments, a plurality of steps or methods may be stored in a memory and achieved by software or firmware executed by a suitable instruction executing system. For example, if it is realized by the hardware, likewise in another embodiment, the steps or methods may be realized by one or a combination of the following techniques known in the art: a discrete logic circuit having a logic gate circuit for realizing a logic function of a data signal, an application-specific integrated circuit having an appropriate combination logic gate circuit, a programmable gate array (PGA), a field programmable gate array (FPGA), etc.

[0079] Those skilled in the art shall understand that all or parts of the steps in the above exemplifying method of the present disclosure may be achieved by commanding the related hardware with programs. The programs may be stored in a computer readable memory medium, and the programs comprise one or a combination of the steps in the method embodiments of the present disclosure when run on a computer.

[0080] In addition, each function cell of the embodiments of the present disclosure may be integrated in a processing module, or these cells may be separate physical existence, or two or more cells are integrated in a processing module. The integrated module may be realized in a form of hardware or in a form of software function

modules. When the integrated module is realized in a form of software function module and is sold or used as a standalone product, the integrated module may be stored in a computer readable memory medium.

[0081] The above-mentioned memory medium may be a read-only memory, a magnetic disc, an optical disc, etc. Although explanatory embodiments have been shown and described, it would be appreciated that the above embodiments are explanatory and cannot be construed to limit the present disclosure, and changes, alternatives, and modifications can be made in the embodiments without departing from scope of the present disclosure by those skilled in the art.

Claims

1. A method for controlling frequency of a variable-frequency compressor in a heat pump water heater, comprising:

   detecting a water temperature of water flowing out from a heat exchanger and a water tank temperature of a water tank;
   determining a preset water temperature of the water flowing out from the heat exchanger according to the water tank temperature; and
   controlling the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature.

2. The method according to claim 1, wherein the preset water temperature is determined according to:

$$T1S=f(T5),$$

   where T1S is the preset water temperature and T5 is the water tank temperature.

3. The method according to claim 2, wherein T1S is computed according to:

$$T1S=a1*a2*a3*T5+b,$$

   where a1 is a first correction factor for a water-water heat exchanger in the water tank, a2 is a second correction factor for a capacity of a heat pump group, a3 is a third correction factor, and b is a temperature difference correction factor.

4. The method according to claim 1, wherein controlling the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature comprises:

   acquiring a temperature difference between the water temperature and the preset water temperature;
   determining a temperature range comprising the temperature difference, and acquiring a correction value according to the temperature range; and
   determining a target frequency of the variable-frequency compressor according to the frequency of the variable-frequency compressor and the correction value.

5. The method according to claim 4, further comprising:

   comparing the target frequency of the variable-frequency compressor with a working frequency of the heat pump group in a set of working frequencies; and
   acquiring a working frequency closest to the target frequency, and determining the working frequency closest to the target frequency as the target frequency.

6. The method according to claim 5, wherein determining the working frequency closest to the target frequency as the target frequency further comprises:

   acquiring a minimum working frequency and a maximum working frequency of the heat pump group under the water tank temperature;
   comparing the working frequency with the minimum working frequency and the maximum working frequency respectively; and
   determining the working frequency as the target frequency if the working frequency is between the minimum working frequency and the maximum working frequency.

7. The method according to claim 6, wherein acquiring a minimum working frequency and a maximum working frequency of the heat pump group under the water tank temperature further comprises:

   determining the minimum working frequency and the maximum working frequency according to an outdoor temperature T4 and the water tank temperature T5;
   determining the minimum working frequency and the maximum working frequency according to a first preset frequency range, if the outdoor temperature T4 is smaller than or equal to a first preset temperature threshold and the water tank temperature T5 is greater than or equal to a second preset temperature threshold or if the outdoor temperature T4 is greater than a third preset temperature threshold and the water tank temperature T5 is greater than or equal to the second preset temperature threshold such that

the variable-frequency compressor is working at the frequency in the first preset frequency range, wherein the first preset temperature threshold is smaller than the third preset temperature threshold; and
determining the minimum working frequency and the maximum working frequency according to a second preset frequency range, if the outdoor temperature T4 is in a first preset temperature range and the water tank temperature T5 is in a second preset temperature range such that the variable-frequency compressor is working at the frequency in the second preset frequency range, wherein the first preset frequency range is narrower than the second preset frequency range.

8. The method according to claim 6, further comprising:

determining the maximum working frequency as the target frequency if the working frequency is greater than the maximum working frequency; and
determining the minimum working frequency as the target frequency if the working frequency is smaller than the minimum working frequency.

9. A system for controlling frequency of a variable-frequency compressor in a heat pump water heater, comprising:

the variable-frequency compressor;
a heat exchanger connected to the variable-frequency compressor;
a first temperature sensor disposed at a water outlet of the heat exchanger, configured to detect a water temperature of water flowing out from the heat exchanger;
a water tank connected to the heat exchanger;
a second temperature sensor disposed in the water tank, configured to detect a water tank temperature; and
a controller, configured to acquire the water temperature from the first temperature sensor and the water tank temperature from the second temperature sensor, and to determine a preset water temperature of the water flowing out from the heat exchanger according to the water tank temperature, and to control the frequency of the variable-frequency compressor according to the water temperature and the preset water temperature.

10. The system according to claim 9, wherein the controller determines the preset water temperature according to:

$$T1S=f(T5),$$

where T1S is the preset water temperature and T5 is the water tank temperature.

11. The system according to claim 10, wherein T1S is computed according to:

$$T1S=a1*a2*a3*T5+b,$$

where a1 is a first correction factor for a water-water heat exchanger in the water tank, a2 is a second correction factor for a capacity of a heat pump group, a3 is a third correction factor, and b is a temperature difference correction factor.

12. The system according to claim 9, wherein the controller is configured to:

acquire a temperature difference between the water temperature and the preset water temperature;
determine a temperature range comprising the temperature difference, and acquire a correction value according to the temperature range; and
determine a target frequency of the variable-frequency compressor according to the frequency of the variable-frequency compressor and the correction value.

13. The system according to claim 12, wherein the controller is further configured to:

compare the target frequency of the variable-frequency compressor with a working frequency of the heat pump group in a set of working frequencies; and
acquire a working frequency closest to the target frequency, and determine the working frequency closest to the target frequency as the target frequency.

14. The system according to claim 13, wherein the controller is further configured to:

acquire a minimum working frequency and a maximum working frequency of the heat pump group under the water tank temperature;
compare the working frequency with the minimum working frequency and the maximum working frequency respectively; and
determine the working frequency as the target frequency if the working frequency is between the minimum working frequency and the maximum working frequency.

15. The system according to claim 14, wherein the controller is further configured to:

determine the minimum working frequency and the maximum working frequency according to an outdoor temperature T4 and the water tank temperature T5;
determine the minimum working frequency and the maximum working frequency according to a first preset frequency range, if the outdoor temperature T4 is smaller than or equal to a first preset temperature threshold and the water tank temperature T5 is greater than or equal to a second preset temperature threshold or if the outdoor temperature T4 is greater than a third preset temperature threshold and the water tank temperature T5 is greater than or equal to the second preset temperature threshold such that the variable-frequency compressor is working at the frequency in the first preset frequency range, wherein the first preset temperature threshold is smaller than the third preset temperature threshold; and
determine the minimum working frequency and the maximum working frequency according to a second preset frequency range, if the outdoor temperature T4 is in a first preset temperature range and the water tank temperature T5 is in a second preset temperature range such that the variable-frequency compressor is working at the frequency in the second preset frequency range, wherein the first preset frequency range is narrower than the second preset frequency range.

16. The system according to claim 14, wherein the controller is further configured to:

determine the maximum working frequency as the target frequency if the working frequency is greater than the maximum working frequency; and
determine the minimum working frequency as the target frequency if the working frequency is smaller than the minimum working frequency.

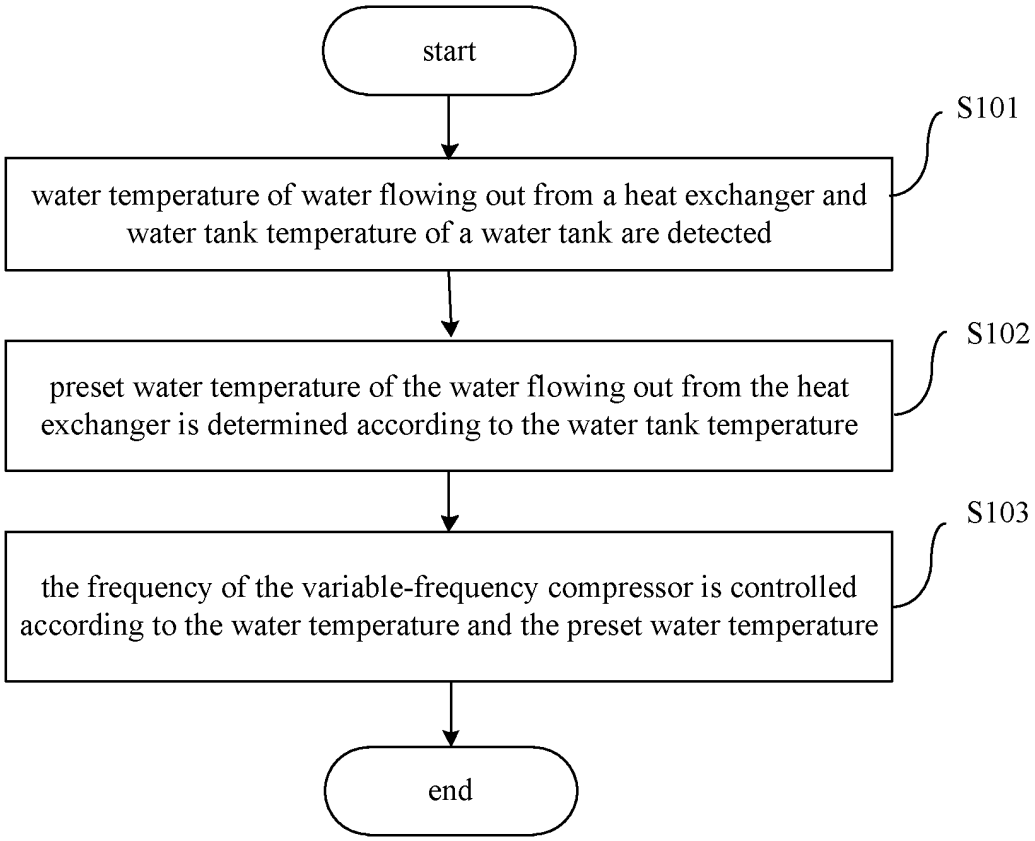
start
S101
water temperature of water flowing out from a heat exchanger and water tank temperature of a water tank are detected
S102
preset water temperature of the water flowing out from the heat exchanger is determined according to the water tank temperature
S103
the frequency of the variable-frequency compressor is controlled according to the water temperature and the preset water temperature
end

Fig. 1

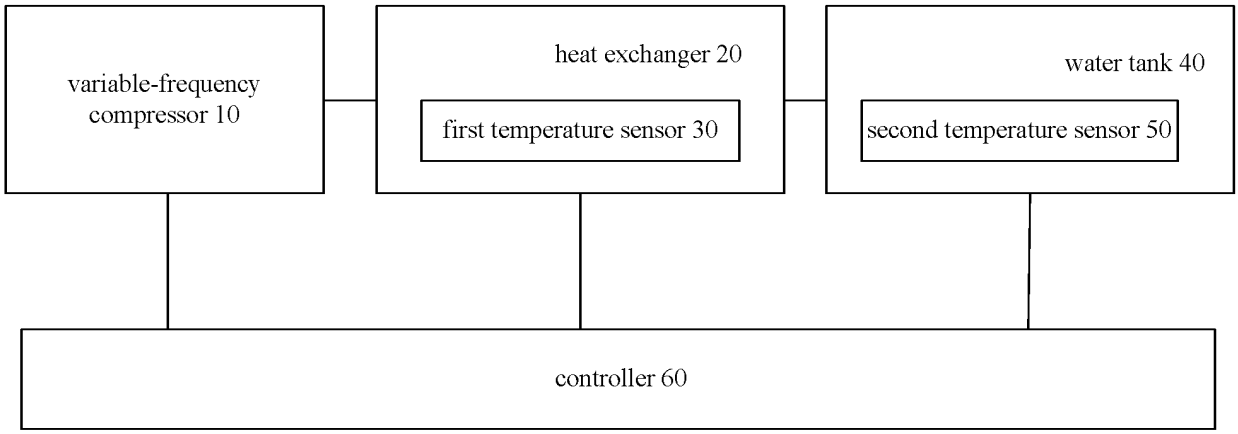
variable-frequency compressor 10
heat exchanger 20
first temperature sensor 30
water tank 40
second temperature sensor 50
controller 60

Fig. 2

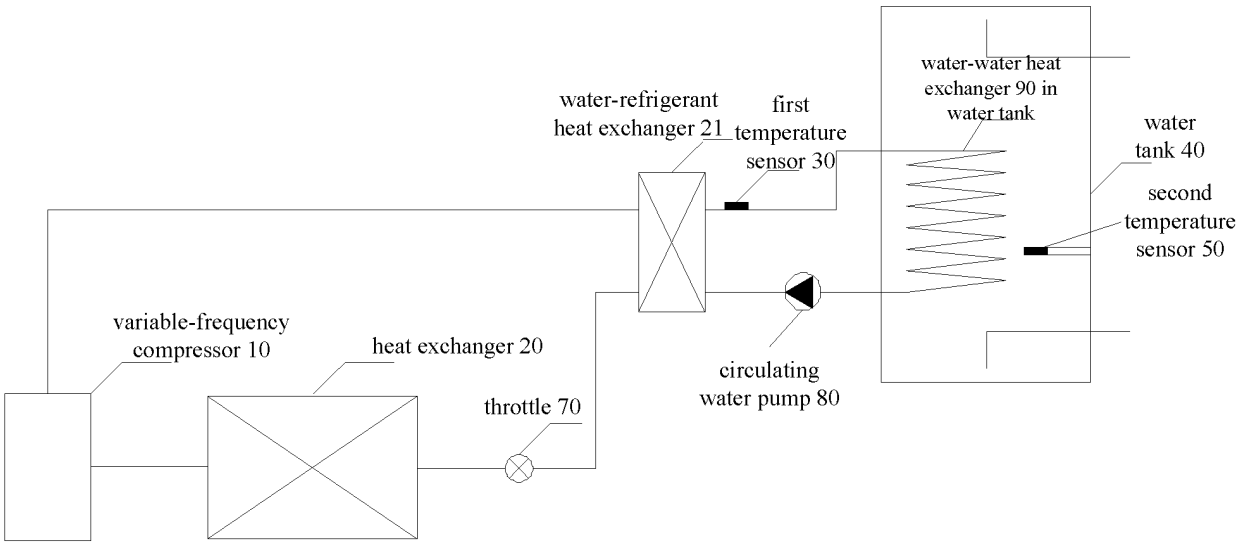
water-water heat
exchanger 90 in
water tank
water-refrigerant
heat exchanger 21
first
temperature
sensor 30
water
tank 40
second
temperature
sensor 50
variable-frequency
compressor 10
heat exchanger 20
throttle 70
circulating
water pump 80

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/084252

A. CLASSIFICATION OF SUBJECT MATTER

F24H 9/20 (2006.01) i; F25B 49/02 (2006.01) i
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24H; F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC:heat pump water heater, compressor, variable-frequency, frequency, heat exchanger, condenser, tank, block, temperature, setting

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102818364 A (HUANG, Ran) 12 December 2012 (12.12.2012) description, paragraphs [0025] to [0034] and figure 1	1-16
A	CN 101846389 A (UNIV SOOCHOW et al.) 29 September 2010 (29.09.2010) the whole document	1-16
A	CN 101957067 A (JIANGSU TENESUN ELECTRICAL APPLIANCE CO., LTD.) 26 January 2011 (26.01.2011) the whole document	1-16

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 January 2016	17 February 2016
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer LIU, Huaitao Telephone No. (86-10) 62084782

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/084252

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2008039353 A (MATSUSHITA ELECTRIC IND CO., LTD.) 21 February 2008 (21.02.2008) the whole document	1-16
A	JP 2012149834 A (MITSUBISHI HEAVY IND LTD.) 09 August 2012 (09.08.2012) the whole document	1-16
A	JP 2006317038 A (MATSUSHITA ELECTRIC IND CO., LTD.) 24 November 2006 (24.11.2006) the whole document	1-16

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/084252

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102818364 A	12 December 2012	None	
CN 101846389 A	29 September 2010	CN 101846389 B	23 May 2012
CN 101957067 A	26 January 2011	CN 101957067 B	05 September 2012
CN 103836789 A	04 June 2014	None	
JP 2008039353 A	21 February 2008	JP 5034367 B2	26 September 2012
JP 2012149834 A	09 August 2012	EP 2479516 A2	25 July 2012
		EP 2479516 A3	02 April 2014
JP 2006317038 A	24 November 2006	None	

Form PCT/ISA /210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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