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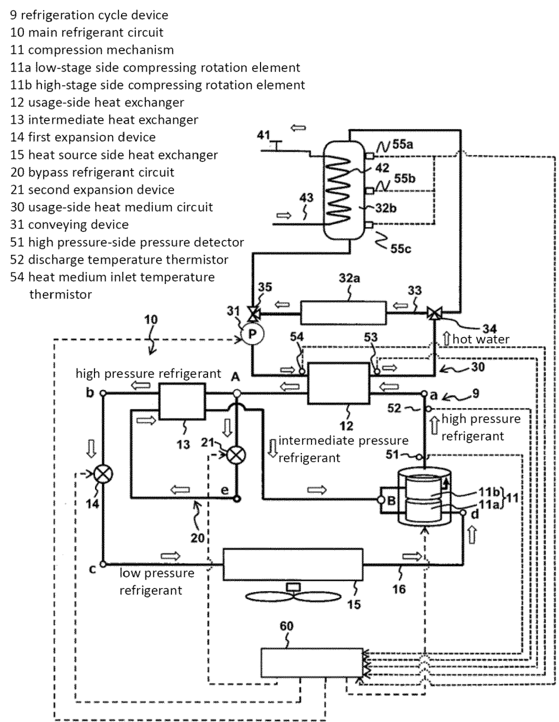
(54) HEAT PUMP SYSTEM

(57) The present invention provides a heat pump system including: a main refrigerant circuit 10 formed from a compression mechanism 11, a usage-side heat exchanger 12, an intermediate heat exchanger 13, a first expansion device 14 and a heat source side heat exchanger 15; a bypass refrigerant circuit 20 branched off from a pipe 16 between the usage-side heat exchanger 12 and the first expansion device 14, in which branched refrigerant is decompressed by a second expansion device 21 and thereafter, heat of the refrigerant is exchanged with that of refrigerant flowing through the main refrigerant circuit 10 by the intermediate heat exchanger 13, and the refrigerant joins up refrigerant which is in the middle of a compression operation of the compressing rotation element; and a control device 60, wherein when temperature of heat medium which flows into the usage-side heat exchanger 12 rises, the control device 60 controls a valve opening of at least the second expansion device 21 to increase a ratio of an amount of refrigerant flowing through the bypass refrigerant circuit 20 to an amount of refrigerant flowing on a side of the main refrigerant circuit 10 of the intermediate heat exchanger 13, and even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises, deterioration of COP is suppressed by performing appropriate control.

[Fig. 1]



Description

[TECHNICAL FIELD]

[0001] The present invention relates to a heat pump system whose a high-pressure side is operated under supercritical pressure.

[BACKGROUND TECHNIQUE]

[0002] As conventional refrigeration cycle devices of this kind, there is one including a refrigerant circuit and an intermediate injection circuit. The refrigerant circuit uses refrigerant whose a high-pressure side becomes supercritical pressure, and the refrigerant circuit is formed by annularly connecting, to one another through a pipe, a two-stage compressing type compressor, a heating heat exchanger which heats hot water, a cooler, a first electric expansion valve and an evaporator. The intermediate injection circuit branches off from the refrigerant circuit between the heating heat exchanger and the cooler. The intermediate injection circuit includes a second electric expansion valve and the cooler in the middle of the refrigerant circuit. The intermediate injection circuit returns a portion of refrigerant discharged from the heating heat exchanger to an intermediate portion between a low-pressure side and a high-pressure side of the compressor.

[0003] This refrigeration cycle device includes a first temperature detection sensor which detects high-pressure side refrigerant discharge temperature of the compressor, a second temperature detection sensor which detects refrigerant temperature of an outlet of the heating heat exchanger, and a third temperature detection sensor which detects refrigerant temperature of an outlet of the cooler. When detected temperature which is detected by the first temperature detection sensor is within a first predetermined temperature range, control is performed such that an opening degree of the first electric expansion valve is maintained, and when a difference between detected temperature detected by the second temperature detection sensor and detected temperature detected by the third temperature detection sensor is within a second predetermined temperature range, control is performed such that an opening degree of the second electric expansion valve is maintained. According to this, a circulation amount of refrigerant which flows into the intermediate injection circuit is suppressed within a constant range, and an expected refrigerant circuit can be formed.

[0004] If a heating load of a heating appliance is reduced, returning temperature of water to a heating heat exchanger from a hot water circuit rises, and refrigerant discharge temperature of high-stage side rotation compressing element also rises. Therefore, control is performed such that the refrigerant discharge temperature of the high-stage side rotation compressing element is lowered by opening the first electric expansion valve (see patent document 1 for example).

[PRIOR ART DOCUMENT]

[PATENT DOCUMENT]

[0005] [Patent Document 1]
Japanese Patent Application Laid-open No.2008-008499

[SUMMARY OF THE INVENTION]

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0006] However, according to the conventional configuration, in the refrigeration cycle device whose high-pressure side is under supercritical pressure and having the heating heat exchanger which heats hot water and the intermediate injection circuit, there is a problem that COP of the refrigeration cycle device is lowered when the returning temperature of water to the heating heat exchanger rises, but technique for suppressing this phenomenon is not disclosed.

[0007] The present invention is achieved to solve the conventional problem, and it is an object of the invention to provide a heat pump system in which even if temperature of usage-side heat medium which flows into a usage-side heat exchanger rises, a high-pressure side which suppresses deterioration of COP is operated under supercritical pressure by performing appropriate control.

[MEANS FOR SOLVING THE PROBLEM]

[0008] To solve the conventional problem, the present invention provides a heat pump system including: a main refrigerant circuit formed by sequentially connecting, through a pipe, a compression mechanism composed of a compression rotation element, a usage-side heat exchanger for heating usage-side heat medium by refrigerant which is discharged from the compression rotation element and which exceeds critical pressure, an intermediate heat exchanger, a first expansion device, and a heat source-side heat exchanger; a bypass refrigerant circuit branched off from the pipe between the usage-side heat exchanger and the first expansion device, in which branched refrigerant is decompressed by a second expansion device and thereafter, heat of the refrigerant is exchanged with that of the refrigerant flowing through the main refrigerant circuit by the intermediate heat exchanger, and the refrigerant joins up with the refrigerant which is in middle of a compression operation of the compression rotation element; and a control device, wherein when temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, the control device controls a valve opening of at least the second expansion device, and increases a ratio of an amount of the refrigerant which flows through the bypass refrigerant circuit to an amount of the refrigerant which flows on the side of a main refrigerant circuit of the intermediate heat exchanger.

[0009] According to this, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, since an amount of refrigerant which circulates through the bypass refrigerant circuit, the high-stage side compressing rotation element and the usage-side heat exchanger is increased, it is possible to suppress deterioration of heating ability in the usage-side heat exchanger.

[0010] Further, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, since a heat exchanging amount between high pressure refrigerant which flows through the main refrigerant circuit and intermediate pressure refrigerant which flows through the bypass refrigerant circuit in the intermediate heat exchanger is increased, it is possible to suppress the reduction in an enthalpy difference between an outlet of refrigerant and an inlet of refrigerant in the usage-side heat exchanger.

[0011] Hence, even if temperature of usage-side heat medium which flows into a usage-side heat exchanger rises, it is possible to provide a heat pump system whose high-pressure side which suppresses deterioration of COP is operated under supercritical pressure.

[EFFECT OF THE INVENTION]

[0012] According to the present invention, it is possible to provide a heat pump system whose high-pressure side which suppresses deterioration of COP is operated under supercritical pressure by performing appropriate control even if temperature of usage-side heat medium which flows into a usage-side heat exchanger rises.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0013]

Fig. 1 is a block diagram of a heat pump system according to an embodiment of the present invention;

Fig. 2 is a pressure-enthalpy diagram (P-h diagram) of a refrigeration cycle device in the embodiment of the invention; and

Fig. 3 is a pressure-enthalpy diagram (P-h diagram) of the refrigeration cycle device when temperature of usage-side heat medium which flows into a usage-side heat exchanger rises in the heat pump system in the embodiment of the invention.

[MODE FOR CARRYING OUT THE INVENTION]

[0014] Claim 1 of the present invention provides a heat pump system Including: a main refrigerant circuit formed by sequentially connecting, through a pipe, a compression mechanism composed of a compression rotation element, a usage-side heat exchanger for heating usage-side heat medium by refrigerant which is discharged from the compression rotation element and which exceeds critical pressure, an intermediate heat exchanger, a first expansion device, and a heat source-side heat exchanger; a bypass refrigerant circuit branched off from the pipe between the usage-side heat exchanger and the first expansion device, in which branched refrigerant is decompressed by a second expansion device and thereafter, heat of the refrigerant is exchanged with that of the refrigerant flowing through the main refrigerant circuit by the intermediate heat exchanger, and the refrigerant joins up with the refrigerant which is in middle of a compression operation of the compression rotation element; and a control device, wherein when temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, the control device controls a valve opening of at least the second expansion device, and increases a ratio of an amount of the refrigerant which flows through the bypass refrigerant circuit to an amount of the refrigerant which flows on the side of a main refrigerant circuit of the intermediate heat exchanger.

[0015] According to this, even if temperature of usage-side heat medium which flows into the usage-side heat exchanger rises, since a heat exchanging amount between high pressure refrigerant which flows through the main refrigerant circuit and intermediate pressure refrigerant which flows through the bypass refrigerant circuit in the intermediate heat exchanger increases, it is possible to suppress the reduction of an enthalpy difference between an outlet and an inlet of refrigerant in the usage-side heat exchanger.

[0016] Further, since an amount of refrigerant which circulates through the bypass refrigerant circuit, the high-stage side compressing rotation element and the usage-side heat exchanger increases, it is possible to suppress deterioration of heating ability in the usage-side heat exchanger.

[0017] Hence, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, it is possible to provide a heat pump system whose high-pressure side which suppress the deterioration of COP is operated under supercritical pressure.

[0018] According to claim 2, the heat pump system of claim 1 further comprises a heat medium inlet temperature thermistor for detecting the temperature of the usage-side heat medium which flows into the usage-side heat exchanger, wherein when detected temperature which is detected by the heat medium inlet temperature thermistor rises, the control device operates to increase the valve opening of the second expansion device.

[0019] According to this, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, since the amount of refrigerant which circulates through the bypass refrigerant circuit, the high-stage side compressing rotation element and the usage-side heat exchanger increases, it is possible to suppress the deterioration of the heating ability in the usage-side heat exchanger.

[0020] According to claim 3, in the heat pump system of claim 2, the control device operates to reduce a valve opening of the first expansion device.

[0021] According to this, the pressure of the high-pressure side of refrigerant of the main refrigerant circuit rises. Therefore, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, it is possible to suppress the reduction of the enthalpy difference between the outlet of refrigerant and inlet of refrigerant in the usage-side heat exchanger.

[0022] According to claim 4, the heat pump system of claim 3 further includes a discharge temperature thermistor which detects temperature of the refrigerant discharged from the compressing rotation element, wherein the control device brings the temperature detected by the discharge temperature thermistor close to a target value by adjusting the valve opening of the first expansion device and the valve opening of the second expansion device.

[0023] According to this, it is possible to increase the heat exchanging amount between the high pressure refrigerant which flows through the main refrigerant circuit and the intermediate pressure refrigerant which flows through the bypass refrigerant circuit in the intermediate heat exchanger, and to increase the amount of refrigerant which circulates through the bypass refrigerant circuit, the high-stage side compressing rotation element and the usage-side heat exchanger while preventing excessive rise or reduction of discharge temperature of refrigerant which is discharged from the compressing rotation element.

[0024] Hence, it is possible to realize the discharge temperature of stable refrigerant, and even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, it is possible to suppress the reduction of the enthalpy difference between the outlet of refrigerant and inlet of refrigerant in the usage-side heat exchanger, and suppress deterioration of the heating ability in the usage-side heat exchanger.

[0025] According to claim 5, the heat pump system of claim 3 further includes a high pressure-side pressure detector which detects pressure of the refrigerant discharged from the compressing rotation element, wherein the control device brings a pressure value detected by the high pressure-side pressure detector close to a target value by adjusting the valve opening of the first expansion device and the valve opening of the second expansion device.

[0026] According to this, it is possible to prevent excessive rise or reduction of pressure of refrigerant which is discharged from the compressing rotation element, and even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, it is possible to suppress the reduction of the enthalpy difference between the outlet of refrigerant and the inlet of refrigerant in the usage-side heat exchanger.

[0027] According to claim 6, the heat pump system of any one of claims 1 to 5 further includes a usage-side heat medium circuit which includes a conveying device and which circulates the usage-side heat medium by the conveying device.

[0028] According to this, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger rises, it is possible to suppress the deterioration of COP, and to provide a heat pump system capable of utilizing high temperature usage-side heat medium and whose high-pressure side is operated under supercritical pressure.

[0029] According to claim 7, in the heat pump system of any one of claims 1 to 6, the usage-side heat medium is water or antifreeze liquid.

[0030] According to this, it is possible to store high temperature water in the hot water tank, and to provide a heat pump system whose high-pressure side which heats a room using the high temperature water is operated under supercritical pressure.

[0031] An embodiment of the present invention will be described below with reference to the drawings. The invention is not limited to the embodiment.

[0032] Fig. 1 is a block diagram of a heat pump system according to the embodiment of the invention. The heat pump system is composed of a refrigeration cycle device 9 which is a supercritical vapor compressing type refrigeration cycle, and a usage-side heat medium circuit 30. The refrigeration cycle device 9 is composed of a main refrigerant circuit 10 and a bypass refrigerant circuit 20.

[0033] The main refrigerant circuit 10 is formed by sequentially connecting, through a pipe 16, a compression mechanism 11 which compresses refrigerant, a usage-side heat exchanger 12 which is a radiator, an intermediate heat exchanger 13, a first expansion device 14 and a heat source-side heat exchanger 15 which is an evaporator. Carbon dioxide (CO_2) is used as refrigerant.

[0034] The compression mechanism 11 is composed of a low stage-side compression rotation element 11a and a high stage-side compression rotation element 11b. The usage-side heat exchanger 12 heats usage-side heat medium by refrigerant discharged from the high stage-side compression rotation element 11b.

[0035] A volume ratio of the low stage-side compression rotation element 11a and the high stage-side compression rotation element 11b which configure the compression mechanism 11 is constant, these rotation elements use a common driving shaft (not shown), and the rotation elements are composed of a single compressor placed in one container.

[0036] This embodiment is described using a two-stage compression mechanism 11 in which the compression rotation element is composed of the low stage-side compression rotation element 11a and the high stage-side compression rotation element 11b, but the present invention can be applied also to a single compression mechanism in which the compressing rotation element is not divided into the low-stage side compressing rotation element 11a and the high-stage side compressing rotation element 11b.

[0037] Here, when a single compression mechanism is employed, a position where refrigerant from the bypass refrigerant circuit 20 joins up is defined as a middle position of being compressed by the compression rotation element, a portion of the compression rotation element up to a position where refrigerant from the bypass refrigerant circuit 20 joins up is defined as the low stage-side compression rotation element 11a, and a portion of the compression rotation element after the position where the refrigerant from the bypass refrigerant circuit 20 joins up is defined as the high stage-side compression rotation element 11b.

[0038] The low-stage side compressing rotation element 11a and the high-stage side compressing rotation element 11b may be a two-stage compression mechanism 11 which is composed of independent two compressors.

[0039] The bypass refrigerant circuit 20 branches off from the pipe 16 between the usage-side heat exchanger 12 and the first expansion device 14, and is connected to the pipe 16 between the low stage-side compression rotation element 11a and the high stage-side compression rotation element 11b.

[0040] The bypass refrigerant circuit 20 is provided with a second expansion device 21. A portion of high pressure refrigerant after it passes through the usage-side heat exchanger 12, or a portion of high pressure refrigerant after it passes through the intermediate heat exchanger 13 is decompressed by the second expansion device 21, and becomes intermediate pressure refrigerant and after that, this refrigerant is heat-exchanged with high pressure refrigerant which flows through the main refrigerant circuit 10 by the intermediate heat exchanger 13, and the refrigerant joins up with refrigerant between the low stage-side compression rotation element 11a and the high stage-side compression rotation element 11b.

[0041] The usage-side heat medium circuit 30 is formed by sequentially connecting the usage-side heat exchanger 12, a conveying device 31 which is a conveying pump, and the heating terminal 32a through a heat medium pipe 33. Water of antifreeze liquid is used as the usage-side heat medium.

[0042] The usage-side heat medium circuit 30 in this embodiment includes a hot water storage tank 32b in parallel to the heating terminal 32a. The usage-side heat medium circuit 30 circulates the usage-side heat medium through the heating terminal 32a or a hot water storage tank 32b by switching between a first switching valve 34 and a second switching valve 35. The usage-side heat medium circuit 30 may include any one of the heating terminal 32a and the hot water storage tank 32b.

[0043] High temperature water produced by the usage-side heat exchanger 12 radiates heat in the heating terminal 32a and is utilized for heating a room, and low temperature water whose heat is radiated in the heating terminal 32a is again heated by the usage-side heat exchanger 12.

[0044] High temperature water produced by the usage-side heat exchanger 12 is introduced into the hot water storage tank 32b from an upper portion of the hot water storage tank 32b, low temperature water is sent out from a lower portion of the hot water storage tank 32b and heated by the usage-side heat exchanger 12.

[0045] A hot water supplying heat exchanger 42 is placed in the hot water storage tank 32b, and the hot water supplying heat exchanger 42 exchanges heat between supplied water from a water supplying pipe 43 and high temperature water in the hot water storage tank 32b. That is, if a hot water supplying plug 41 is opened, water is supplied from the water supplying pipe 43 into the hot water supplying heat exchanger 42, the water is heated by the hot water supplying heat exchanger 42, temperature of the water is adjusted to predetermined temperature by the hot water supplying plug 41, and hot water is supplied from the hot water supplying plug 41.

[0046] Water is supplied from the water supplying pipe 43 and heated by the hot water supplying heat exchanger 42, and hot water supplied from the hot water supplying plug 41 and high temperature water in the hot water storage tank 32b are not mixed with each other, and they are indirectly heated.

[0047] The hot water supplying heat exchanger 42 is a water heat exchanger using a copper pipe or stainless steel pipe as a heat transfer pipe, and the water supplying pipe 43 extending from a water supplying source (running water) and the hot water supplying plug 41 are connected to the hot water supplying heat exchanger 42 as shown in Fig. 1. The water supplying pipe 43 sends normal temperature water into a lower end of the hot water supplying heat exchanger 42, i.e., into a lower portion in the hot water storage tank 32b.

[0048] The normal temperature water sent into the hot water supplying heat exchanger 42 from the water supplying pipe 43 draws heat from the high temperature water in the hot water storage tank 32b while moving upward in the hot water storage tank 32b from downward, and the normal temperature water becomes high temperature heated water and is supplied from the hot water supplying plug 41.

[0049] To measure temperature of hot water at a plurality of different height positions, the hot water storage tank 32b is provided with a plurality of hot water storage tank temperature thermistors, e.g., a first hot water storage tank temperature thermistor 55a, a second hot water storage tank temperature thermistor 55b and a third hot water storage tank temperature thermistor 55c.

[0050] The normal temperature water which enters the hot water supplying heat exchanger 42 from the water supplying pipe 43 draws heat from high temperature water in the hot water storage tank 32b while moving upward in the hot water storage tank 32b from downward. Therefore, temperature of hot water in the hot water storage tank 32b naturally becomes high at an upper portion and lower at a low portion in the hot water storage tank 32b.

[0051] The main refrigerant circuit 10 is provided with a high pressure-side pressure detector 51 and a discharge temperature thermistor 52 in the pipe 16 on the discharge side of the high stage-side compression rotation element 11b.

[0052] The high pressure-side pressure detector 51 is provided in the main refrigerant circuit 10 from a discharge side of the high stage-side compression rotation element 11b to an upstream side of the first expansion device 14. It is only necessary that the high pressure-side pressure detector 51 can detect pressure of high pressure refrigerant in the main refrigerant circuit 10.

[0053] Further, the discharge temperature thermistor 52 is also provided in the main refrigerant circuit 10 from the discharge side of the high-stage side compressing rotation element 11b to the upstream side of the first expansion device 14. It is also only necessary that the discharge temperature thermistor 52 can detect temperature of the high pressure refrigerant of the main refrigerant circuit 10.

[0054] The usage-side heat medium circuit 30 includes a heat medium inlet temperature thermistor 54 for detecting temperature of usage-side heat medium which flows into the usage-side heat exchanger 12.

[0055] The control device 60 controls operation frequencies of the low-stage side compressing rotation element 11a and the high-stage side compressing rotation element 11b, a valve opening of the first expansion device 14, a valve opening of the second expansion device 21 and a conveying amount of the usage-side heat medium conveyed by the conveying device 31 based on detected pressure detected by the high pressure-side pressure detector 51, detected temperature detected by the discharge temperature thermistor 52 and detected temperature detected by the heat medium inlet temperature thermistor 54.

[0056] Fig. 2 is a pressure-enthalpy diagram (P-h diagram) under the ideal condition concerning the refrigeration cycle device in the embodiment.

[0057] Points a to e and points A and B in Fig. 2 correspond to points in the refrigeration cycle device shown in Fig. 1.

[0058] First, high pressure refrigerant (point a) discharged from the high stage-side compression rotation element 11b radiates heat in the usage-side heat exchanger 12 and after that, the high pressure refrigerant branches off from the main refrigerant circuit 10 at a refrigerant branch point (point A), the high pressure refrigerant is decompressed to intermediate pressure by the second expansion device 21 and becomes intermediate pressure refrigerant (point e), and the intermediate pressure refrigerant is heat-exchanged by the intermediate heat exchanger 13.

[0059] The high pressure refrigerant which flows through the main refrigerant circuit 10 after it radiates heat by the usage-side heat exchanger 12 is cooled by intermediate pressure refrigerant (point e) which flows through the bypass refrigerant circuit 20, and the high pressure refrigerant is decompressed by the first expansion device 14 in a state (point b) where enthalpy thereof is reduced.

[0060] According to this, refrigerant enthalpy of refrigerant (point c) which flows into the heat source-side heat exchanger 15 after it is decompressed by the first expansion device 14 is also reduced. Dryness (weight ratio occupied by gas phase component to the entire refrigerant) of refrigerant when it flows into the heat source-side heat exchanger 15 is reduced and liquid component of refrigerant is increased. Therefore, this contributes to evaporation in the heat source-side heat exchanger 15, a refrigerant ratio is increased and an endothermic energy amount from outside air is increased, and it returns to the suction side (point d) of the low stage-side compression rotation element 11a.

[0061] On the other hand, refrigerant of an amount corresponding to gas phase component which does not contribute to evaporation in the heat source-side heat exchanger 15 is made to bypass by the bypass refrigerant circuit 20, and becomes low temperature intermediate pressure refrigerant (point e), the refrigerant is heated by high pressure refrigerant which flows through the main refrigerant circuit 10 in the intermediate heat exchanger 13, and the refrigerant reaches a refrigerant joining point B located between the low stage-side compression rotation element 11a and the high stage-side compression rotation element 11b in a state where refrigerant enthalpy is increased.

[0062] Therefore, on the suction side of the high stage-side compression rotation element 11b (point B), since refrigerant pressure is higher than that on the suction side of the low stage-side compression rotation element 11a (point d), refrigerant density is also high, and refrigerant which joins up with refrigerant discharged from the low stage-side compression rotation element 11a is sucked, further compressed by the high stage-side compression rotation element 11b and is discharged. Therefore, a flow rate of the refrigerant which flows into the usage-side heat exchanger 12 is largely increased, and ability of heating water which is usage-side heat medium is largely enhanced.

[0063] A case where the hot water storage tank 32b is used in the usage-side heat medium circuit 30 will be described below.

[0064] Among the plurality of hot water storage tank temperature thermistors, if detected temperature detected by the first hot water storage tank temperature thermistor 55a which is placed at the highest position in the hot water storage tank 32b is lower than a predetermined value, the control device 60 determines that high temperature water is insufficient in the hot water storage tank 32b.

[0065] The control device 60 operates the low stage-side compression rotation element 11a and the high stage-side compression rotation element 11b and heats low temperature water by the usage-side heat exchanger 12. The control device 60 operates the conveying device 31 such that detected temperature detected by the heat medium outlet temperature thermistor 53 which is heating producing temperature becomes equal to the target temperature.

[0066] With this, low temperature water which is sent out from the lower portion of the hot water storage tank 32b is heated by the usage-side heat exchanger 12. According to this, high temperature water is produced, and the high temperature water is introduced into the hot water storage tank 32b from the upper portion of the hot water storage tank 32b.

[0067] Since high temperature water is gradually stored in the hot water storage tank 32b from the upper portion, detected temperature detected by the heat medium inlet temperature thermistor 54 gradually increases.

[0068] A case where the heating terminal 32a is used in the usage-side heat medium circuit 30 will be described.

[0069] The control device 60 operates the low stage-side compression rotation element 11a and the high stage-side compression rotation element 11b and heats circulated water by the usage-side heat exchanger 12, and the control device 60 operates the conveying device 31 such that a temperature difference, which is the temperature difference of the circulated water, between detected temperature detected by the heat medium outlet temperature thermistor 53 and detected temperature detected by the heat medium inlet temperature thermistor 54 becomes equal to a target temperature difference.

[0070] According to this, high temperature water produced by the usage-side heat exchanger 12 radiates heat in the heating terminal 32a and is utilized for heating a room, and low temperature water whose heat is released by the heating terminal 32a is again heated by the usage-side heat exchanger 12. At that time, since control is performed such that a temperature difference between detected temperature detected by the heat medium outlet temperature thermistor 53 and detected temperature detected by the heat medium inlet temperature thermistor 54 becomes equal to the target temperature difference.

[0071] Since the heating load is gradually reduced, control is performed such that a temperature difference between detected temperature detected by the heat medium outlet temperature thermistor 53 and detected temperature detected by the heat medium inlet temperature thermistor 54 becomes equal to the target temperature difference. Therefore, the detected temperature detected by the heat medium outlet temperature thermistor 53 and the detected temperature detected by the heat medium inlet temperature thermistor 54 increase gradually.

[0072] A case where temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 in the usage-side heat medium circuit 30, i.e., a case where detected temperature detected by the heat medium inlet temperature thermistor 54 rises will be described below using Fig. 3.

[0073] In Fig. 3, a solid line is a pressure-enthalpy diagram when temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises with respect to broken lines.

[0074] In Fig. 3, if temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises, inlet temperature (point a) of refrigerant toward the usage-side heat exchanger 12 moves to an increasing direction (point a') of enthalpy. Further, outlet temperature (point A) of refrigerant from the usage-side heat exchanger 12 moves to the increasing direction (point A') of enthalpy.

[0075] Similarly, outlet temperature (point B) of refrigerant from the bypass refrigerant circuit 20 of the intermediate heat exchanger 13 also moves to the increasing direction (point B') of enthalpy. Further, inlet temperature (point e) of refrigerant toward the bypass refrigerant circuit 20 of the intermediate heat exchanger 13 also moves to the increasing direction (point e') of enthalpy.

[0076] In a state where pressure exceeds critical pressure, if temperature moves to the increasing direction of enthalpy, inclination of isothermal line with respect to pressure also becomes steep.

[0077] Hence, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises, to suppress the deterioration of COP of the refrigeration cycle device 9, the control device 60 must control the valve opening of the second expansion device 21 such that a temperature difference between the outlet temperature (point B') of refrigerant from the bypass refrigerant circuit 20 of the intermediate heat exchanger 13 and the inlet temperature (point e') of refrigerant toward the bypass refrigerant circuit 20 to the intermediate heat exchanger 13 does not become as small as possible in the intermediate heat exchanger 13.

[0078] Further, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises, it is necessary that heating ability of the usage-side heat medium is not deteriorated as small as possible by refrigerant which is discharged from the high-stage side compressing rotation element 11b in the usage-side heat exchanger 12.

[0079] More specifically, a ratio of an amount of refrigerant which flows through the bypass refrigerant circuit 20 to an amount of refrigerant which flows on the side of the main refrigerant circuit 10 of the intermediate heat exchanger 13 is increased.

[0080] That is, the valve opening of the second expansion device 21 is increased and a ratio of an amount of refrigerant which circulates through the bypass refrigerant circuit 20, the high-stage side compressing rotation element 11b and the usage-side heat exchanger 12 to an amount of refrigerant which circulates through the main refrigerant circuit 10 is increased.

[0081] According to this, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises, the heat exchanging amount between the high pressure refrigerant which flows through the main refrigerant circuit 10 and the intermediate pressure refrigerant which flows through the bypass refrigerant circuit 20 in the intermediate heat exchanger 13 is increased.

[0082] Hence, it is possible to suppress the reduction of an enthalpy difference (point a' to point A') between the outlet of refrigerant and the inlet of refrigerant in the usage-side heat exchanger 12.

[0083] The enthalpy difference between the high pressure refrigerant (point a') discharged from the high-stage side compressing rotation element 11b and the refrigerant (point A') of a branch point of refrigerant after heat is released at the usage-side heat exchanger 12 is equal to a total of an enthalpy difference between refrigerant (point B') on the suction side of the high-stage side compressing rotation element 11b and the intermediate pressure refrigerant (point e') which flows through the bypass refrigerant circuit 20 and an enthalpy difference of the high-stage side compressing rotation element 11b.

[0084] Hence, in order to increase the enthalpy difference (point a' to point A') between the outlet of refrigerant and the inlet of refrigerant in the usage-side heat exchanger 12, it is necessary to increase the enthalpy difference (point B' to point e') of the bypass refrigerant circuit 20 of the intermediate heat exchanger 13.

[0085] Since the amount of refrigerant which circulates through the bypass refrigerant circuit 20, the high-stage side compressing rotation element 11b and the usage-side heat exchanger 12 is increased, it is possible to suppress the deterioration of the heating ability in the usage-side heat exchanger 12.

[0086] The control device 60 operates to reduce the valve opening of the first expansion device 14. According to this, since pressure on the high-pressure side of refrigerant of the main refrigerant circuit 10 rises, even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises, it is possible to suppress the reduction of the enthalpy difference (point a' to point A') between the outlet of refrigerant and the inlet of refrigerant in the usage-side heat exchanger 12.

[0087] The control device 60 adjusts the valve opening of the first expansion device 14 and the valve opening of the second expansion device 21. According to this, temperature detected by the discharge temperature thermistor 52 is brought close to a target value. The target value of discharge temperature is preset in the control device 60.

[0088] According to this, it is possible to prevent the discharge temperature of refrigerant discharged from the high-stage side compressing rotation element 11b from being excessively increased or reduced, it is possible to increase the heat exchanging amount between the high pressure refrigerant which flows through the main refrigerant circuit 10 and the intermediate pressure refrigerant which flows through the bypass refrigerant circuit 20 in the intermediate heat exchanger 13, and it is possible to increase the amount of refrigerant which circulates through the bypass refrigerant circuit 20, the high-stage side compressing rotation element 11b and the usage-side heat exchanger 12.

[0089] The control device 60 adjusts the valve opening of the first expansion device 14 and the valve opening of the second expansion device 21. According to this, a pressure value detected by the high pressure-side pressure detector 51 is brought close to a target value.

[0090] According to this, it is possible to prevent pressure of refrigerant discharged from the high-stage side compressing rotation element 11b from being excessively increased or reduced. Even if temperature of the usage-side heat medium which flows into the usage-side heat exchanger 12 rises, it is possible to suppress the reduction of the enthalpy difference (point a' to point A') between the outlet of refrigerant and the inlet of refrigerant in the usage-side heat exchanger 12.

[0091] The compressing rotation element may be a single compressing rotation element which is not divided into the low-stage side compressing rotation element 11a and the high-stage side compressing rotation element 11b. If the single compressing rotation element is employed, a position where refrigerant from the bypass refrigerant circuit 20 joins up is defined as a middle position of being compressed by the compression rotation element.

[0092] By using water or antifreeze liquid as usage-side heat medium, it is possible to use the usage-side heat medium in the heating terminal 32a or high temperature water can be stored in the hot water tank 32b.

[INDUSTRIAL APPLICABILITY]

[0093] As described above, according to the heat pump system of the present invention whose high-pressure side is operated under supercritical pressure, even if temperature of usage-side heat medium which flows into a usage-side heat exchanger rises, deterioration of COP is suppressed by performing appropriate control. Therefore, the heat pump system is suitable for refrigerating equipment, an air conditioner, a hot water supply system, heating equipment and the like.

[EXPLANATION OF SYMBOLS]

[0094]

9	refrigeration cycle device
10	main refrigerant circuit
11	compression mechanism
11a	low stage-side compression rotation element
11b	high stage-side compression rotation element
12	usage-side heat exchanger
13	intermediate heat exchanger
14	first expansion device
15	heat source-side heat exchanger
16	pipe
20	bypass refrigerant circuit
21	second expansion device
30	usage-side heat medium circuit
31	conveying device
32a	heating terminal
32b	hot water storage tank
33	heat medium pipe
34	first switching valve

35	second switching valve
41	hot water supplying plug
42	hot water supplying heat exchanger
43	water supplying pipe
51	high pressure-side pressure detector
52	intermediate pressure-side pressure detector
53	heat medium outlet temperature thermistor
54	heat medium inlet temperature thermistor
55a	first hot water storage tank temperature thermistor
55b	second hot water storage tank temperature thermistor
55c	third hot water storage tank temperature thermistor
60	control device

Claims

1. A heat pump system comprising:

   a main refrigerant circuit (10) formed by sequentially connecting, through a pipe (16), a compression mechanism (11) composed of a compression rotation element (11a, 11b), a usage-side heat exchanger (12) for heating usage-side heat medium by refrigerant which is discharged from the compression rotation element (11a, 11b) and which exceeds critical pressure, an intermediate heat exchanger (13), a first expansion device (14), and a heat source-side heat exchanger (15);
   a bypass refrigerant circuit (20) branched off from the pipe (16) between the usage-side heat exchanger (12) and the first expansion device (14), in which branched refrigerant is decompressed by a second expansion device (21) and thereafter, heat of the refrigerant is exchanged with that of the refrigerant flowing through the main refrigerant circuit (10) by the intermediate heat exchanger (13), and the refrigerant joins up with the refrigerant which is in middle of a compression operation of the compression rotation element (11a, 11b); and
   a control device (60), wherein
   when temperature of the usage-side heat medium which flows into the usage-side heat exchanger (12) rises, the control device (60) controls a valve opening of at least the second expansion device (21), and increases a ratio of an amount of the refrigerant which flows through the bypass refrigerant circuit (20) to an amount of the refrigerant which flows on a side of the main refrigerant circuit (10) of the intermediate heat exchanger (13).

2. The heat pump system according to claim 1, further comprising a heat medium inlet temperature thermistor (54) for detecting the temperature of the usage-side heat medium which flows into the usage-side heat exchanger (12), wherein when detected temperature which is detected by the heat medium inlet temperature thermistor (54) rises, the control device (60) operates to increase the valve opening of the second expansion device (21).

3. The heat pump system according to claim 2, wherein the control device (60) operates to reduce a valve opening of the first expansion device (14).

4. The heat pump system according to claim 3, further comprising a discharge temperature thermistor (52) which detects temperature of the refrigerant discharged from the compressing rotation element (11a, 11b), wherein the control device (60) brings the temperature detected by the discharge temperature thermistor (52) close to a target value by adjusting the valve opening of the first expansion device (14) and the valve opening of the second expansion device (21) .

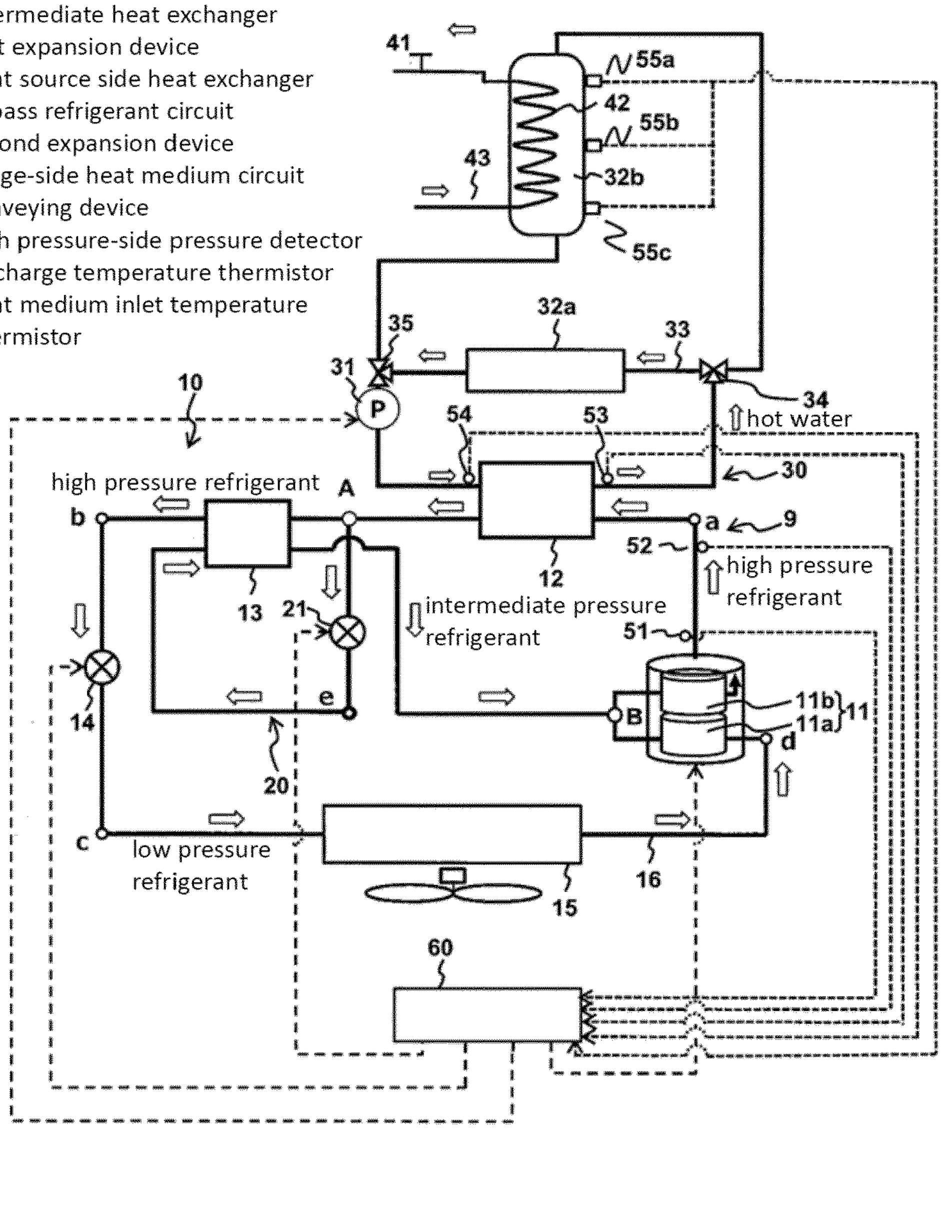
5. The heat pump system according to claim 3, further comprising a high pressure-side pressure detector (51) which detects pressure of the refrigerant discharged from the compressing rotation element (11a, 11b), wherein the control device (60) brings a pressure value detected by the high pressure-side pressure detector (51) close to a target value by adjusting the valve opening of the first expansion device (14) and the valve opening of the second expansion device (21) .

6. The heat pump system according to any one of claims 1 to 5, further comprising a usage-side heat medium circuit (30) which includes a conveying device (31) and which circulates the usage-side heat medium by the conveying device (31) .

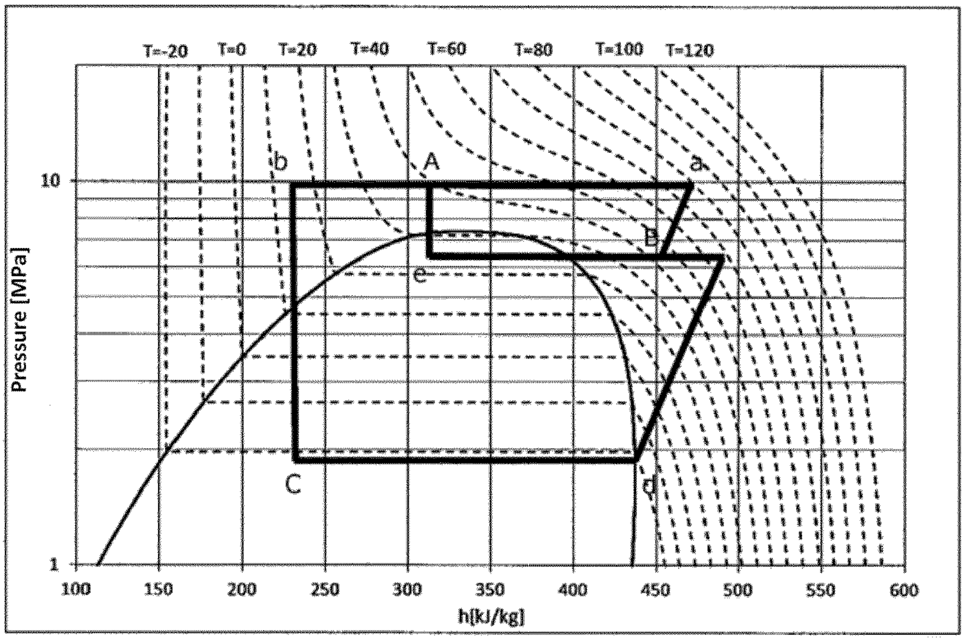
7. The heat pump system according to any one of claims 1 to 6, wherein the usage-side heat medium is water or antifreeze liquid.

[Fig. 1]

9 refrigeration cycle device
10 main refrigerant circuit
11 compression mechanism
11a low-stage side compressing rotation element
11b high-stage side compressing rotation element
12 usage-side heat exchanger
13 intermediate heat exchanger
14 first expansion device
15 heat source side heat exchanger
20 bypass refrigerant circuit
21 second expansion device
30 usage-side heat medium circuit
31 conveying device
51 high pressure-side pressure detector
52 discharge temperature thermistor
54 heat medium inlet temperature thermistor



[Fig. 2]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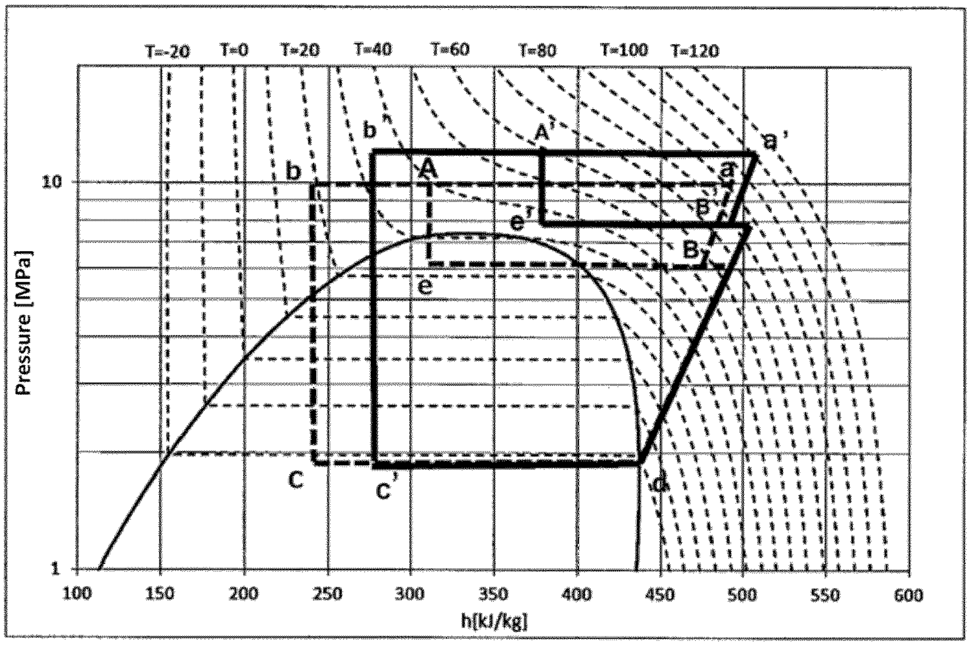
h[kJ/kg]

[Fig. 3]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EUROPEAN SEARCH REPORT

Application Number
EP 20 20 6234

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F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	21 April 2021	Schopfer, Georg

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