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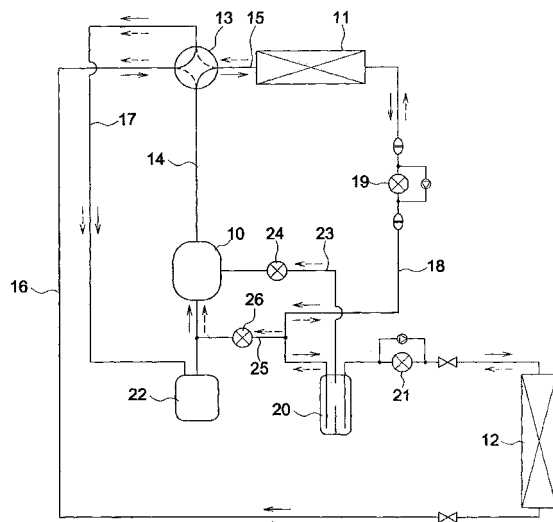
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(54) **Air conditioning system**

(57) An air conditioning system for heating and cooling air. The air conditioning system, which is provided with a compressor (10) for compressing a refrigerant, an outdoor heat exchanger (11) for heat-exchanging the refrigerant with outdoor air, an indoor heat exchanger (12) for heat-exchanging the refrigerant with indoor air, a four-way valve (13) for converting the direction of a refrigerant flow, a refrigerant expansion device (19) installed in a refrigerant pipe connecting the outdoor heat exchanger and the indoor heat exchanger, and a vapour-liquid separator (20) installed in a refrigerant pipe connecting the refrigerant expansion device and the in-

door heat exchanger, includes a liquid refrigerant supply pipe (25) connecting the vapour-liquid separator and an inlet of the compressor for supplying the refrigerant in a liquid state within the vapour-liquid separator to the inlet of the compressor, and a liquid refrigerant supply valve (26) for controlling the supply of the refrigerant in the liquid state through the liquid refrigerant supply pipe. The air conditioning system has an improved capacity and reduces a compression ratio and a discharge temperature of the compressor in a heating mode under the condition that an outdoor temperature is extremely low, thus increasing reliability of the compressor.

FIG 1



Description

[0001] The present invention relates to an air conditioning system operable to heat air, comprising a compressor, an outdoor heat-exchanger, an indoor heat exchanger, an expansion device and a vapour-liquid separator

[0002] Air conditioning systems which can operate in either a heating or a cooling mode generally comprise a compressor, an outdoor heat exchanger, a refrigerant expansion means, an indoor heat exchanger, and a four-way valve. In the cooling mode, a refrigerant is discharged from the compressor and supplied to the outdoor heat exchanger, and the four-way valve is set so that the refrigerant passes through the indoor heat exchanger and is introduced into an inlet of the compressor. In this cycle, the refrigerant is in a high-temperature and high-pressure state from being compressed by the compressor and is introduced into the outdoor heat exchanger to be condensed into a liquid state. It then passes through the refrigerant expansion means where it is expanded to a low-pressure state. The low pressure refrigerant then flows onwards to the indoor heat exchanger where it is evaporated to a gaseous state and it then passes to the inlet of the compressor. In this process, the refrigerant at the outdoor heat exchanger emits heat by heat-exchanging with outdoor air, and the refrigerant at the indoor heat exchanger absorbs heat by heat-exchanging with indoor air, thereby cooling an indoor room.

[0003] In the heating mode of the air conditioning system, the refrigerant is discharged from the compressor and supplied to the indoor heat exchanger, and the four-way valve is set so as to divert the refrigerant through the outdoor heat exchanger and into the inlet of the compressor. Accordingly, the refrigerant in a high-temperature and high-pressure state compressed by the compressor is introduced into the indoor heat exchanger where it is condensed into a liquid state. The condensed refrigerant then passes through the refrigerant expansion means where it is expanded to a low-pressure state. The low pressure refrigerant then passes to the outdoor heat exchanger where it is evaporated to a gaseous state and it then flows toward the inlet of the compressor. In this heating process, the refrigerant at the indoor heat exchanger emits heat by heat-exchanging with the indoor air, and the refrigerant at the outdoor heat exchanger absorbs heat by heat-exchanging with the outdoor air, thereby heating the indoor room.

[0004] In the heating mode, if the outdoor temperature is extremely low (for example, lower than -10°C), the pressures at high and low sides in the air conditioning system are decreased, thus preventing the air conditioning system from working at maximum capacity. In such low outdoor temperature conditions, the pressure at the low-pressure side of the outdoor heat exchanger must be lowered so that the temperature of the refrigerant is lower than the outdoor temperature for heat-exchanging

to occur from the outdoor air to the refrigerant. In this case, since the refrigerant introduced into the inlet of the compressor has a low density, it is difficult to increase a discharge pressure of the compressor to a high pressure. Further, the low discharge pressure of the compressor makes it difficult to raise the temperature of the refrigerant at the indoor heat exchanger, thus decreasing the heating effects of the air conditioning system.

[0005] In the heating mode, the lower the pressure at the low side (at the outdoor heat exchanger) and the higher the pressure at the high side (at the indoor heat exchanger), the better the heating capacity of the above air conditioning system is. However, such an excessive difference between the pressures at the low and high sides is detrimental to the reliability of the compressor.

[0006] Furthermore, in the heating mode, when the outdoor temperature is extremely low, the compressor will get excessively hot if it is to run at maximum capacity and this reduces the reliability of the compressor as it is more likely to break under such stresses.

[0007] Therefore, an object of the invention is to provide an air conditioning system for heating and cooling air, which has an improved heating capacity and improved compressor reliability.

[0008] In accordance with the present invention, the above and other objects can be accomplished by the provision of an air conditioning system operable to heat air, comprising a compressor, an outdoor heat-exchanger, an indoor heat exchanger, an expansion device and a vapour-liquid separator, characterised by a first refrigerant supply pipe connecting the vapour-liquid separator to the compressor to supply refrigerant to the compressor from the vapour-liquid separator.

[0009] The air conditioning system preferably includes a first control valve is located in the first refrigerant supply pipe to control the amount of refrigerant supplied to the compressor through said first refrigerant supply pipe.

[0010] In a preferred embodiment, the first refrigerant supply pipe is connected to a liquid outlet of the vapour-liquid separator to supply refrigerant in a liquid state to the inlet of the compressor. Alternatively, the first refrigerant supply pipe may be connected to a vapour outlet of the vapour-liquid separator to supply refrigerant in a gaseous state to the compressor.

[0011] A second refrigerant supply pipe preferably connects the vapour outlet of the vapour-liquid separator to the compressor to supply refrigerant in the gaseous state to the compressor from the vapour-liquid separator. In an alternative embodiment, however, the second refrigerant supply pipe may connect the liquid outlet of the vapour-liquid separator to the compressor to supply refrigerant in the liquid state to the inlet of the compressor from the vapour-liquid separator.

[0012] Conveniently, a second control valve is located in the second refrigerant supply pipe to control the amount of refrigerant supplied to the compressor.

[0013] A preferred embodiment of the present inven-

tion will now be described with reference to the accompanying drawing, in which:

Figure 1 is a schematic view illustrating a cycle of an air conditioning system for heating and cooling air in accordance with the present invention.

[0014] As shown in Figure 1, an air conditioning system for heating and cooling air comprises a scroll compressor 10 for compressing a refrigerant in a liquid state to a high-temperature and high-pressure state, an outdoor heat exchanger 11 for heat-exchanging the circulating refrigerant with outdoor air, an indoor heat exchanger 12 for heat-exchanging the circulating refrigerant with indoor air, and a four-way valve 13 for directing the flow of the refrigerant so that it flows selectively into either the outdoor heat exchanger 11 or the indoor heat exchanger 12. The four-way valve 13 includes four connection ports respectively connected to an outlet of the compressor 10 by a refrigerant pipe 14, to the outdoor heat exchanger 11 by a refrigerant pipe 15, to the indoor heat exchanger 12 by a refrigerant pipe 16, and to an inlet of the compressor 10 by a refrigerant pipe 17.

[0015] A first refrigerant expansion device 19 for expanding the refrigerant by decompression is installed in the middle of a refrigerant pipe 18 for connecting the indoor heat exchanger 12 and the outdoor heat exchanger 11. A vapour-liquid separator 20 is installed between the first refrigerant expansion device 19 and the indoor heat exchanger 12, and a second refrigerant expansion device 21 is installed between the vapour-liquid separator 20 and the indoor heat exchanger 12. An accumulator 22 for minimizing the flow of the refrigerant in the liquid state into the compressor 10 is installed in the refrigerant pipe 17 that is connected to the inlet of the compressor 10.

[0016] The air conditioning system further comprises a gaseous refrigerant supply pipe 23 connecting the vapour-liquid separator 20 and the compressor 10, and a gaseous refrigerant supply valve 24, installed in the gaseous refrigerant supply pipe 23, for controlling the supply of the refrigerant in the gaseous state through the gaseous refrigerant supply pipe 23. The system is thereby operable to supply refrigerant in a gaseous state, separated by the vapour-liquid separator 20, to the compressor 10 in a heating mode when the outdoor temperature is extremely low, so the refrigerant in a comparatively high-density and high-pressure gaseous state is supplied to the compressor 10, thus allowing a compression ratio of the compressor 10 to be reduced and increasing the reliability of the compressor 10. Furthermore, the amount of refrigerant circulating toward the indoor heat exchanger 12 in a comparatively high-pressure state is increased, thus improving heating effects of the air conditioning system, and the amount of refrigerant in a liquid state circulating toward the outdoor heat exchanger 11 is decreased, thus improving heat exchanging capacity of the outdoor heat exchanger 11.

[0017] The air conditioning system of the present invention is also operable to supply the refrigerant in a liquid state, separated by the vapour-liquid separator 20, to the inlet of the compressor 10 in the heating mode when the outdoor temperature is even lower than that in the above-described case. To achieve this, the air conditioning system further comprises a liquid refrigerant supply pipe 25 for connecting the vapour-liquid separator 20 and the compressor 10, and a liquid refrigerant supply valve 26, installed in the liquid refrigerant supply pipe 25, for controlling the supply of the refrigerant in the liquid state through the liquid refrigerant supply valve 26. The degree to which the liquid refrigerant supply valve 26 is opened is controlled such that the refrigerant in the liquid state supplied to the inlet of the compressor 10 is sprayed in a decompressed state. Thereby, an amount of the refrigerant circulating toward the indoor heat exchanger 12 in the heating mode is increased, thus increasing the reliability of the compressor 10 and improving heating effects of the air conditioning system. Further, the refrigerant in the liquid state supplied to the inlet of the compressor 10 is evaporated in the compressor 10, thus preventing an extreme increase in temperature in the compressor 10.

[0018] Hereinafter, operations of cooling and heating modes of the air conditioning system of the present invention will be described in detail. In Figure 1, arrows shown by a solid line illustrate the flow of the refrigerant in the cooling mode, and arrows shown by a dotted line illustrate the flow of the refrigerant in the heating mode.

[0019] In the cooling mode, the refrigerant discharged from the compressor 10 is supplied to the outdoor heat exchanger 11, and the four-way valve 13 directs the flow of the refrigerant that has passed through the indoor heat exchanger 12, into the inlet of the compressor 10. The first refrigerant expansion device 19 is completely opened, and the gaseous refrigerant supply valve 24 and the liquid refrigerant supply valve 26 are closed. Accordingly, the refrigerant in a high-temperature and high-pressure state compressed by the compressor 10 is introduced into the outdoor heat exchanger 11 to be condensed into a liquid state, from where the condensed refrigerant passes through the first refrigerant expansion device 19 without decompression and is then introduced into the vapour-liquid separator 20. The refrigerant in the liquid state passed through the vapour-liquid separator 20 then passes through the second refrigerant expansion device 21 so that it is expanded into a low-temperature state, and is then introduced into the indoor heat exchanger 12 so that it is evaporated into a gaseous state. The refrigerant in the gaseous state then flows back toward the inlet of the compressor 10. In this cycle, the refrigerant in the high-temperature state at the outdoor heat exchanger 11 is condensed by heat-exchanging with the outdoor air, and emits heat. The refrigerant in the low-temperature state in the indoor heat exchanger 12 is evaporated by heat-exchanging with the indoor air, and absorbs heat. Thereby, the cooling

mode of the air conditioning system of the present invention is achieved.

[0020] In the heating mode, the refrigerant discharged from the compressor 10 is supplied to the indoor heat exchanger 12, and the four-way valve 13 is operated to divert the flow of the refrigerant that has passed through the outdoor heat exchanger 11, into the inlet of the compressor 10. Whereas the gaseous refrigerant supply valve 24 and the liquid refrigerant supply valve 26 are normally closed in the heating mode, the gaseous refrigerant supply valve 24 is opened to a specific degree if the outdoor temperature is extremely low (for example, lower than -10°C).

[0021] Accordingly, the refrigerant in the high-temperature and high-pressure state compressed by the compressor 10 is introduced into the indoor heat exchanger 12 so that the refrigerant is condensed into a liquid state, and the condensed refrigerant passes through the second refrigerant expansion device 21 where it is decompressed into a middle-pressure state, and is then introduced into the vapour-liquid separator 20. The refrigerant in a liquid state, separated by the vapour-liquid separator 20, passes through the first refrigerant expansion device 19 so that the refrigerant is decompressed and expanded, and is introduced into the outdoor heat exchanger 11 to be evaporated into a gaseous state. Then, the refrigerant in the gaseous state flows back toward the inlet of the compressor 10. In this cycle, the refrigerant in the high-temperature state at the indoor heat exchanger 12 is condensed by heat-exchanging with the indoor air, and emits heat to the indoor room. The refrigerant in the low-temperature state at the outdoor heat exchanger 11 is evaporated by heat-exchanging with the outdoor air, and absorbs heat.

[0022] In addition, the refrigerant in the middle-pressure state is supplied from the vapour-liquid separator 20 to the compressor 10, and this refrigerant, together with the refrigerant supplied to the inlet of the compressor 10 from the outdoor heat exchanger 11, is compressed by the compressor 10 and circulated toward the indoor heat exchanger 12. Therefore, the amount of refrigerant in the high-pressure state circulating in the indoor heat exchanger 12 is more than the amount of the refrigerant in the low-pressure state circulating in the outdoor heat exchanger 11. Accordingly, the air conditioning system of the present invention reduces a difference (a compression ratio) between a suction pressure and a discharge pressure of the compressor 10, thus increasing the reliability of the compressor 10. Furthermore, the amount of the refrigerant circulating toward the indoor heat exchanger 12 is increased, thus allowing the high pressure in the indoor heat exchanger 12 to be maintained and increasing the heating effect of the air conditioning system. Also, only the refrigerant in the liquid state, separated by the vapour-liquid separator 20, passes through the first refrigerant expansion device 19 and is expanded by decompression, so the refrigerant is more easily expanded and thereby increases the heat

exchanging efficiency of the outdoor heat exchanger 11. Although the capacity of the outdoor heat exchanger 11 is the same for both the heating mode and the cooling mode, the amount of the refrigerant circulating in the outdoor heat exchanger 11 in the heating mode is less than the amount of refrigerant circulating in the outdoor heat exchanger 11 in the cooling mode. Accordingly, since the air conditioning system of the present invention has the effect of expanding the capacity of the outdoor heat exchanger 11, the heat exchanging efficiency of the outdoor heat exchanger 11 of the air conditioning system is remarkably improved compared to that of conventional air conditioning systems, thus increasing operating efficiency in the heating mode.

[0023] In the heating mode, if the outdoor temperature is even lower than that of the above-described case (for example, lower than -15°C), the liquid refrigerant supply valve 26 is opened to a small degree together with the above-described opening of the gaseous refrigerant supply valve 24 such that some of the refrigerant in the liquid state flowing from the vapour-liquid separator 20 to the first refrigerant expansion device 19, is instead diverted to be supplied to the inlet of the compressor 10. Therefore, the amount of the refrigerant circulating toward the indoor heat exchanger 12 is increased and the amount of the refrigerant circulating toward the outdoor heat exchanger 11 is correspondingly decreased, thus improving the heating effect of the air conditioning system. In this case, the refrigerant in the liquid state supplied to the inlet of the compressor 10 is evaporated in the compressor 10, thus preventing the excessive rise of the temperature of the compressor 10. Since the excessive rise of the temperature at the outlet of the compressor 10 is prevented, even when the compressor 10 is running at maximum capacity in the heating mode when the outdoor temperature is extremely low, the air conditioning system of the present invention has greater reliability and stability over that of known air conditioning systems. Also, since the compressor 10 is a scroll compressor, which is capable of compressing a refrigerant in a liquid state, the inflow of a small amount of the refrigerant in the liquid state into the compressor 10 does not cause trouble in the operation of the compressor 10.

[0024] As is apparent from the above description, the present invention provides an air conditioning system for heating and cooling air, in which refrigerant in a gaseous state, separated by a vapour-liquid separator, is supplied to a compressor in a heating mode so as to decrease a compression ratio of the compressor and increase a discharge pressure of the compressor, thus improving heating effects and increasing the reliability of the compressor.

[0025] Since an amount of the refrigerant in a high-pressure state circulating in an indoor heat exchanger in the heating mode is increased, the indoor heat exchanger is maintained in a high-pressure state, thus increasing the heating effects of the air conditioning system. Furthermore, since the amount of refrigerant circu-

lating in the outdoor heat exchanger in the heating mode is decreased, the outdoor heat exchanger is reduced to a lower-pressure state, thus allowing heat exchanging efficiency of the outdoor heat exchanger to be remarkably increased even if the outdoor temperature is extremely low.

[0026] Since the excessive rise of the temperature of the compressor is prevented by the evaporation of the refrigerant in a liquid state supplied to an inlet of the compressor in the heating mode, the air conditioning system of the present invention has improved reliability and stability. In this case, the amount of the refrigerant circulating toward the indoor heat exchanger is further increased and the amount of the refrigerant circulating toward the outdoor heat exchanger is further decreased, thus improving the heating effects of the air conditioning system of the present invention.

[0027] Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope of the invention as disclosed in the accompanying claims.

Claims

1. An air conditioning system operable to heat air, comprising a compressor, an outdoor heat-exchanger, an indoor heat exchanger, an expansion device and a vapour-liquid separator, **characterised by** a first refrigerant supply pipe connecting the vapour-liquid separator to the compressor to supply refrigerant to the compressor from the vapour-liquid separator.
2. An air conditioning device according to claim 1 wherein a first control valve is located in the first refrigerant supply pipe to control the amount of refrigerant supplied to the compressor through said first refrigerant supply pipe.
3. An air conditioning system according to claims 1 or claim 2 wherein the first refrigerant supply pipe is connected to a liquid outlet of the vapour-liquid separator to supply refrigerant in a liquid state to the inlet of the compressor.
4. An air conditioning system according to claim 1 or claim 2 wherein the first refrigerant supply pipe is connected to a vapour outlet of the vapour-liquid separator to supply refrigerant in a gaseous state to the compressor.
5. An air conditioning system according to any of claims 1 to 3 further comprising a second refrigerant supply pipe connecting the vapour outlet of the vapour-liquid separator to the compressor to supply refrigerant in the gaseous state to the compressor from the vapour-liquid separator.
6. An air conditioning system according to any of claims 1, 2 or 4, further comprising a second refrigerant supply pipe connecting the liquid outlet of the vapour-liquid separator to the compressor to supply refrigerant in the liquid state to the inlet of the compressor from the vapour-liquid separator.
7. An air conditioning system according to claim 5 or claim 6 wherein a second control valve is located in the second refrigerant supply pipe to control the amount of refrigerant supplied to the inlet of the compressor through said second refrigerant supply pipe.
8. An air conditioning system for heating and cooling air, provided with a compressor for compressing a refrigerant, an outdoor heat exchanger for heat-exchanging the refrigerant with outdoor air, an indoor heat exchanger for heat-exchanging the refrigerant with indoor air, a four-way valve for converting the direction of a refrigerant flow, a refrigerant expansion device installed in a refrigerant pipe connecting the outdoor heat exchanger and the indoor heat exchanger, and a vapour-liquid separator installed in a refrigerant pipe connecting the refrigerant expansion device and the indoor heat exchanger comprising a liquid refrigerant supply pipe connecting the vapour-liquid separator and an inlet of the compressor for supplying the refrigerant in a liquid state within the vapour-liquid separator to the inlet of the compressor and a liquid refrigerant supply valve for controlling the supply of the refrigerant in the liquid state through the liquid refrigerant supply pipe.
9. The air conditioning system according to claim 8 further comprising a gaseous refrigerant supply pipe connecting the vapour-liquid separator and the compressor for supplying the refrigerant in a gaseous state within the vapour-liquid separator to the compressor and a gaseous refrigerant supply valve for controlling the supply of the refrigerant in the gaseous state through the gaseous refrigerant supply pipe.
10. The air conditioning system according to claim 8 or claim 9 further comprising a second refrigerant expansion device installed in a refrigerant pipe connecting the vapour-liquid separator and the indoor heat exchanger.
11. The air conditioning system according to any of claims 8 to 10 wherein the compressor is a scroll compressor for compressing the refrigerant in the liquid state.

FIG 1

