A control method of a dryer is disclosed. A control method of a dryer including a heat pump having a variable velocity type compressor, the control method includes steps of selecting at least one course supplying air or dried air; increasing an activation velocity of the compressor to a target velocity, as the selected course is implemented; and adjusting an open degree of an expansion valve provided in the heat pump.
FIG. 1
FIG. 2
FIG. 9

Activation Velocity

Target Velocity

Time

T1
FIG. 10

Activation Velocity

Target Velocity

Time

T1

K1 $\frac{\Delta v}{\Delta t}$

K2 $\frac{\Delta v}{\Delta t}$
FIG. 12

Start

Identifying Low Noisy Activation Condition

Adjusting Activation Velocity of Compressor

End
FIG. 13

Compressor Activation Velocity

<table>
<thead>
<tr>
<th>HZ2</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>HZ1</td>
<td></td>
</tr>
</tbody>
</table>

Time

T3

β
FIG. 14

Noise (dB)

30Hz  60Hz  90Hz

30  48  58  63 dB(A)
CONTROL METHOD OF DRYER

CROSS REFERENCE TO RELATED APPLICATION

[0001] Pursuant to 35 U.S.C. §119(a), this application claims the benefit of earlier filing date and right of priority to Korean Patent Application Nos. 10-2010-0039371 filed on Apr. 28, 2010, and 10-2010-0039372 filed on Apr. 28, 2010, 10-2010-0039373 filed on Apr. 28, 2010 and 10-2010-0041999 filed on May 4, 2010, which are hereby incorporated by references as if fully set forth herein.

BACKGROUND OF THE DISCLOSURE

[0002] 1. Field of the Disclosure
[0003] The present invention relates to a control method of a dryer.
[0004] 2. Discussion of the Related Art
[0005] Laundry devices may be categorized into washing machines which can perform washing, dryers which can perform drying and washing machines having a drying function which can perform both washing and drying. Dryers are electric appliances which supply heated air to dry objects to dry them. A variety of dryers have been developed and the dryers accompany a variety of problems.

SUMMARY OF THE DISCLOSURE

[0006] Accordingly, the present invention is directed to a control method of a dryer.
[0007] An object of the present invention is to provide a control method of a dryer which can activate a compressor in initial activation stably. In other words, the object of the present invention is to provide the control method which can prevent liquid refrigerant from flowing into the compressor in the initial activation of the compressor. By extension, the object of the present invention is to provide the control method which can control the quantity of the refrigerant based on temperature information relating to the compressor, to prevent overheat of the compressor.
[0008] Furthermore, another object of the present invention is to provide a control method which can reduce noise and vibration of a dryer. For that, the control method according to the present invention may adjust an activation velocity of a variable velocity type compressor, to reduce the noise and vibration generated in the compressor.
[0009] Additional advantages, objects, and features of the disclosure will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.
[0010] To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a control method of a dryer comprising a heat pump including a variable velocity type compressor, the control method includes steps of: selecting at least one course supplying air or dried air; increasing an activation velocity of the compressor to a target velocity, as the selected course is implemented; and adjusting an open degree of an expansion valve provided in the heat pump.

[0011] In another aspect of the present invention, a dryer includes a user operational part configured to receive at least one piece of drying information; a control unit configured to generate an operation signal based on the drying information input via the user operational part; a heat pump activated based on the operation signal generated in the control unit, the heat pump comprising a compressor and an expansion valve, wherein an activation velocity of the compressor is increased to a preset target velocity for a first time band based on the operation signal and an open degree of the expansion valve is adjusted based on the operation signal for a first time band and a second time band in a serial order.

[0012] It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the disclosure and together with the description serve to explain the principle of the disclosure.
[0014] In the drawings:
[0015] FIG. 1 is a perspective view illustrating an inner configuration of a dryer according to an exemplary embodiment of the present invention;
[0016] FIG. 2 is a perspective view only illustrating a heat pump from FIG. 1;
[0017] FIGS. 3 to 6 are diagram schematically illustrating a configuration of a dryer including a heat pump according to embodiments;
[0018] FIGS. 7 and 8 are diagram illustrating a configuration of a heat pump according to another embodiments; and
[0019] FIGS. 9 and 10 are graphs illustrating driving velocity change of a compressor according to the control method;
[0020] FIG. 11 is a graph illustrating opening degree change of an expansion valve according to the control method;
[0021] FIG. 12 is a flow chart illustrating a control method according to another embodiment;
[0022] FIG. 13 is a graph illustrating a relation between a driving time band and a low noise time band of a compressor; and
[0023] FIG. 14 is a graph illustrating noise based on a driving velocity of the compressor.

DESCRIPTION OF SPECIFIC EMBODIMENTS

[0024] Reference will now be made in detail to the specific embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.
[0025] As follows, a dryer according to an exemplary embodiment of the present invention will be described in detail in reference to the accompanying drawings.
[0026] FIG. 1 is a perspective view illustrating a dryer according to an exemplary embodiment of the present invention.
[0027] In reference to FIG. 1, the dryer 100 according to the embodiment of the present invention includes a cabinet 110 forming an exterior appearance thereof. The dryer 100 further
includes a drum 120 which is selectively rotatable within the cabinet 110. Drying objects may be loaded into the drum 120. Although not shown in the drawings, the dryer 100 may include a user operational part (not shown) to receive at least one piece of drying information input by a user. The user may use the user operational part to select pieces of the drying information, for example, a wished course. The dryer 100 includes a control unit (not shown) generating an operation signal based on the drying information input via the user operational part.

[0028] In the meanwhile, the dryer 100 according to the embodiment may include heating means for supplying dried-air to the drum 120 to dry the drying objects loaded into the drum 120. The dryer 100 according to this embodiment may include a heat pump 130 as the heating means. The heat pump 130 includes an evaporator 132, a compressor (134, see FIG. 3), a condenser 136 and an expansion valve (138, see FIG. 3) where refrigerant is circulated sequentially. The heat pump 130 may dehumidify and dry external air drawn therein and it may heat the dried air to a predetermined temperature. Here, the heat pump 130 is activated based on the operation signal of the control unit.

[0029] As follows, the heat pump 130 will be described in detail.

[0030] FIG. 2 is a perspective view illustrating the configuration of the heat pump 130 according to an embodiment.

[0031] In reference to FIG. 2, the heat pump 130 includes an evaporator 132 and a condenser 136. The evaporator 132 condenses refrigerant, to receive a latent heat from the external air drawn therein and it condenses the moisture of the air, to transmit the latent heat to the condenser 136. The condenser 136 heats the air by using the latent heat transmitted from the evaporator 132 via the refrigerant. In other words, the heat pump 130 according to this embodiment controls the evaporator 132 to dehumidify and the condenser 136 to heat the air to the predetermined temperature, such that it may supply dried/heated air to the drum 120.

[0032] In the meanwhile, each component of the heat pump 130 mentioned above may be installed in a predetermined portion of the cabinet 110 provided in the dryer 100 according to the exemplary embodiment. It is preferable that the heat pump 130 may be a module type mounted in a predetermined portion of the cabinet 110 detachably. The module type heat pump 130 is provided and it is then more efficient to assemble and disassemble the dryer according to this embodiment for maintenance. For that, the heat pump 130 according to this embodiment may include a case 140 for forming a profile of the heat pump 130 and the variety of the components mentioned above may be provided in the case 140.

[0033] The case 140 may include an upper case 142 and a lower case 144. The various components of the heat pump 130 may be installed in the lower case 144. The upper case 142 may be detachably coupled to the lower case 144. Because of that, the installation and repair of the components installed in the case 140 may be performed smooth and efficient.

[0034] The moisture of the air drawn into the case 140 is condensed and the air is dried by the evaporator 132. In other words, the refrigerant is evaporated in a refrigerant pipe of the evaporator 132 and the heat of the air passing outside the evaporator 132 is transmitted to the refrigerant to cool the air. The moisture is condensed into condensate and the air is relieved of the moisture, to be the dried air.

[0035] It is preferable that a condensate storage (not shown) may be further provided to collect the condensate condensed by the evaporator 132. For example, a collecting tank (not shown) is provided below the evaporator 132 to collect the condensate and the collecting tank (not shown) may be connected with the condensate storage located adjacent to the evaporator 132. Because of that, the condensate condensed by the evaporator 132 may be collected in the collecting tank first and it may be stored in the condensate storage via a pipe after that. The condensate storage may be installed in the cabinet 110 to send the collected condensate outside the cabinet 120 via a drainage pipe or it may be detachably installed in the cabinet 110 to allow the user to throw the condensate outside after detaching.

[0036] In the meanwhile, the evaporator 132 may store the latent heat in the refrigerant. At the same time, it may condense the moisture of the air and dry the air. In other words, as the moisture contained in the air is condensed, the refrigerant inside the evaporator 132 is getting gaseous to contain the latent heat. The latent heat contained in such the refrigerant is transmitted to the condenser 136 and it is used to heat the air, which will be described later.

[0037] In other words, the condenser 136 according to this embodiment is connected with the evaporator 132 and the compressor 134 via a refrigerant pipe (not shown). Because of that, the refrigerant including the latent heat inside the evaporator 132 is supplied to the compressor 134 and the condenser 136 sequentially via the refrigerant pipe. The refrigerant is condensed in the condenser 136 and the latent heat is discharged, such that the air passing the condenser 136 may be heated to a predetermined temperature. As a result, the evaporator 132 condenses the moisture contained in the air and it dries the air. Simultaneously, the evaporator 132 transmits the latent heat generated by the condensation of the moisture to the condenser 136 via the refrigerant. The condenser 136 condenses the refrigerant to discharge the latent heat and it then heats the air.

[0038] In the meanwhile, according to this embodiment, a single air path (A) may be formed to guide the air along the evaporator 132 and the condenser 136. In other words, the moisture of the air drawn into the heat pump 130 is condensed and the air is dried. After that, the dried air passes the compressor 134 and it is then heated in the condenser 136, such that the heated air may be supplied to the drum 120. When the single air path (A) is formed, the air supplied to the drum 120 is heated and dried to result in improving a drying effect. Typically, the high temperature as well as the dried air should be supplied to improve the drying effect.

[0039] The shape of the air path (A) where the air is flowing is not limited to a specific one. Considering that the heat pump 130 is installed in the cabinet 110, the air path (A) may be formed in a linear shape. For that, the evaporator 132 and the condenser 136 provided in the heat pump 130 may be arranged linearly along the air path (A). Because of that, the volume of the heat pump 130 can be reduced as much as possible and the assembly/disassembly process of the heat pump 130 may be smooth and efficient. Here, a fan (not shown) may be further provided in the case 132 to blow the air to flow along the air path (A) smoothly.

[0040] As mentioned above, this embodiment presents the air path provided when the case 140 is provided in the heat pump 130. However, in case the components of the heat pump 130 are installed in a predetermined portion of the cabinet 110, without the case 140, an auxiliary duct may be provided
to draw external air to the evaporator 132 and the condenser 136. In the meanwhile, if the air dried and heated by the heat pump 130 is supplied to the drum 120, the air is heated by the condenser 136. Because of that, the temperature of the air supplied by the heat pump 130 of the dryer 100 according to this embodiment may be lower than the temperature of the air supplied by a heater provided in a conventional dryer. Because of that, the dryer according to this embodiment may further include a heater (139, see FIG. 4) to heat the air before drawing the air into the case 140 or the drum 120.

[0041] In addition, this embodiment presents that the single air path (A) is formed along the evaporator 132 and the condenser 136 of the heat pump 130. Alternatively, independent air paths may be formed along the evaporator and the condenser. In other words, the moisture of the air drawn into the evaporator 132 is condensed to store the latent heat and the air is discharged outside the heat pump 130 again. The latent heat is transmitted to the condenser 136 via the latent heat and the air drawn into the condenser 136 along the auxiliary air path may be heated to be supplied to the drum 120.

[0042] In the meanwhile, dryers may be categorized into circulation type dryers and exhaustion type dryers. In a circulation type, air is circulated in the drum and such an exhaustion type uses air exhausted from the drum. As follows, a circulation type dryer including the heat pump and an exhaustion type dryer including the heat pump will be described.

[0043] FIG. 3 is a diagram schematically illustrating a configuration of the circulation type dryer including the heat pump.

[0044] In reference to FIG. 3, air exhausted from the drum 120 is supplied to the evaporator 132 along a first air path 12. The moisture of the air is condensed by the evaporator 132 and the air flows to the condenser 136 along a second air path 14 to be heated to a predetermined temperature by the condenser 136. The air having passed the condenser 136 is re-supplied to the inside of the drum 120 along a third air path 16. Here, the evaporator 132 and the condenser 136 may be connected with the compressor 134 and the expansion valve 138 via a refrigerant line 22. The configuration and operation of the heat pump is explained above and repeated description will be omitted.

[0045] FIG. 4 is a diagram illustrating a circulation type dryer according to another embodiment. According to this embodiment, the air having passed the heat pump is re-heated by a heater 139 before supplied to the drum and this is a different feature, compared with the embodiment of FIG. 3. As follows, this embodiment will be described, focused to the different feature.

[0046] In reference to FIG. 4, the air discharged from the condenser 136 is circulated along a third air path 16 to be supplied to inside of the drum 120 via the heater 139. The heater 139 re-heats the air flowing along the third air path 16. Here, the term of “re-heating” means that the air is heated by the heater 139 secondarily after heated by the condenser 136 firstly.

[0047] Such the heater 139 may be a gas heater or an electric heater, not limited thereto. When the heater is provided, the air dried and heated by the condenser 136 of the heat pump is re-heated by the heater and it is possible to supply the air having a desired temperature to the drum 120. The air is pre-heated by the condenser 136 and heated by the heater. Because of that, load applied to the heater may be reduced noticeably. In other words, the heater uses less electric energy to heat the air to the desired temperature, compared with the heater provided in the conventional dryer, and it is possible to heat the air to the desired temperature by using a compact-sized heater.

[0048] FIG. 5 is a diagram schematically illustrating a configuration of an exhaustion type dryer including the heat pump. Compared with the embodiment of FIG. 3, this embodiment presents a different air path and it will be described, focused to this different feature.

[0049] In reference to FIG. 5, the air having passed the evaporator 132 is exhausted outside the dryer along a fourth air path 17. In other words, different from the circulation type which supplies the air having passed the evaporator 132 to the condenser 136, the exhaustion type dryer exhausts the air outside. In this case, the air exhausted from the drum 120 has a higher temperature than a normal temperature air. When the air exhausted from the drum 120 reaches the evaporator 132, the heat is transmitted to the refrigerant of the evaporator 132 and the latent heat is stored in the refrigerant. Such the refrigerant is supplied to the condenser 136 along the refrigerant line 22 and the air is heated by the latent heat in the condenser 136. Here, the air is drawn to the condenser 136 along a fifth air path 19.

[0050] Not the air exhausted from the drum 120 but internal air or external air of the dryer is flowing along the fifth air path 19.

[0051] FIG. 6 illustrates an exhaustion type dryer according to another embodiment including the heat pump. Compared with the embodiment of FIG. 5, the air having passed the heat pump is re-heated by a heater 139 before supplied to the drum. The exhaustion type dryer is described in reference to FIG. 5 and the heater is described in reference to FIG. 4. Repeated description will be omitted.

[0052] In the meanwhile, the above embodiments present the heat pump including the single evaporator and the single condenser. However, the heat pump may include a plurality of evaporators 132 and a plurality of condensers 136.

[0053] As follows, installation states of the plurality of the condensers 136 and evaporators 132 will be described. FIGS. 7 and are diagrams schematically illustrating a heat pump module including a plurality of condensers 136 and a plurality of evaporators 132.

[0054] In reference to FIG. 7, the number of the evaporators 132 and the number of the condensers 136 may be determined based on an installation environment. For example, two evaporators and two condensers, which will be described as follows.

[0055] The evaporator 132 according to this embodiment includes a first evaporator 132A and a second evaporator 132B. The condenser 136 includes a first condenser 136A and a second condenser 136B. The first and second evaporators 132A and 132B may be arranged adjacent to each other. The first and second condensers 136A and 136B may be also arranged adjacent to each other. Here, the first and second evaporators and the first and second condensers may be arranged in parallel to the air path.

[0056] In the meanwhile, the first and second evaporators 132A and 132B and the first and second condensers 136A and 136B are connected with the compressor 134 by a refrigerant pipe 660. Here, the connection between the refrigerant pipe and the first and second evaporators 132A and 132B and the first and second condensers 136A and 136B may be serial or in parallel.
Here, when the first and second evaporators 132A and 132B and the first and second condensers 136A and 136B are connected with the refrigerant pipe 660 serially, the compressor 134 is connected with the first evaporator 132A via the refrigerant pipe 660 and the first evaporator 132A is connected with the second evaporator 132B via an auxiliary pipe. Because of that, the refrigerant pipe 660 is located from the second evaporator 132B to the expansion valve 138 and the refrigerant pipe is located from the expansion valve 138 to the first condenser 136A. Here, the first condenser 136A is connected with the second condenser 136B via an auxiliary pipe and the refrigerant pipe 660 is located between the second condenser 136B and the compressor 134.

As a result, the refrigerant supplied from the compressor 134 heats the air, while passing the first and second condensers 136A and 136B serially. The refrigerant having passed the first and second condensers 136A and 136B condenses the moisture contained in the air, while passing the expansion valve 138 and the first and second evaporators 132A and 132B sequentially.

In the meanwhile, FIG. 7 shows that the first and second evaporators 132A and 132B are connected with each other serially and that the first and second condensers 136A and 136B are connected with each other serially, too. However, the first and second evaporators 132A and 132B may be connected in parallel and the first and second condensers 136A and 136B may be connected in parallel. FIG. 8 shows the plurality of the evaporators connected with each other in parallel and the plurality of the condensers connected with each other in parallel. As follows, the different feature in comparison to FIG. 7 will be described.

In reference to FIG. 8, the first and second evaporators 132A and 132B are connected with each other in parallel and the first and second condensers 136A and 136B are connected with each other in parallel. In this case, branched pipes 662 and 666 may be further formed in the refrigerant pipe 660 located from the compressor 134 to the first and second evaporators 132A and 132B and in the refrigerant pipe 660 located from the compressor 134 to the first and second condensers 136A and 136B, respectively. In addition, branched pipes 666a and 666b may be further branched in the refrigerant pipe 660 located from the expansion valve 138 to the first and second evaporators 132A and 132B and in the refrigerant pipe 660 located from the expansion valve 138 to the first and second condensers 136A and 136B, respectively.

The branched pipe 662 is connected to an end of the refrigerant pipe 660 located between the compressor 134 and the first and second evaporators 132A and 1132B, such that the refrigerant may be supplied to the first evaporator 132A and the second evaporator 132B via the branched pipe 662 simultaneously. Together with that, the branched pipe 664 is connected to an end of the refrigerant pipe 660 located between the compressor 134 and the first and second condensers 136A and 136B, such that the refrigerant having passed the first and second condensers 136A and 136B may be supplied to the compressor 134 via the branched pipe 664.

The refrigerant supplied by the compressor 134 condenses the moisture contained in the air, while dividedly passing the first and second evaporators 132A and 132B, and it heats the air, while dividedly passing the first and second condensers 136A and 136B.

In reference to FIGS. 7 and 8, again, the moisture of the humid air exhausted from the drum 120 is condensed and removed, while the air is passing the first and second evaporators 132A and 132B sequentially. After that, the humid air is changed into dried air. The dried air exhausted from the evaporator 132 is heated while it is passing the first and second condensers 136A and 136B sequentially. After that, the high temperature dried air having passed the second condenser 136B is re-supplied to the inside of the drum 120. The embodiments of FIGS. 7 and 8 illustrate only the configuration of the circulation type dryer and they may be applicable to the exhaust type dryer. In case of the exhaustion type, the evaporator and condenser shown in FIGS. 5 and 6 may be replaced by the plurality of the evaporators and the plurality of the condensers shown in FIGS. 7 and 8.

In the meanwhile, the dryer according to the exemplary embodiment of the present invention has an effect of improved condensation efficiency, because the humid air exhausted from the drum 120 passes the first evaporator 132A and the second evaporator 132B sequentially. In other words, the humid air passes the first and second evaporators 132A and 132B. Because of that, a contact area and a contact time between the humid air and the refrigerant line of the first and second evaporators 132A and 132B may be increased enough to condense the moisture contained in the humid air as much as possible.

In addition, the dryer according to the exemplary embodiment of the present invention has an effect of increased heating efficiency, because the air passes the first condenser 136A and the second condenser 136B sequentially. Because of that, a contact area and a contact time between the dried air and the refrigerant line of the first and second condensers 136A and 136B may be increased enough to gain a relatively high temperature dried air, compared with the dried air passing the single condenser.

As a result, such the high temperature dried-air is supplied to the inside of the drum 120 to heat-exchange with the drying objects. Then, heat-exchanging efficiency can be enhanced and the drying time can be reduced.

In the meanwhile, the compressor of the heat pump may include a fixed velocity type compressor of which a driving velocity is fixed and a variable velocity type compressor of which an activation velocity is adjusted. Here, the variable velocity type compressor may refer to a compressor having a selectively adjustable activation velocity (Hz), not a fixed activation velocity. As the activation velocity of the compressor 134 is adjusted, noise and vibration of the compressor 134 may be reduced and damage and breakdown of the compressor may be prevented.

However, important elements for adjusting the activation velocity of the variable velocity type compressor 134 may be temperature information of the refrigerant. The temperature information of the refrigerant may include at least one of a refrigerant condensation temperature of the condenser 136, a refrigerant evaporation temperature of the evaporator 132, an exhausted refrigerant temperature of the condenser 136 and drawn/exhausted refrigerant temperature of the evaporator 132. In other words, the control unit (not shown) of the dryer 100 may control an activation velocity of the compressor 134 based on the temperature information on the refrigerant.

As follows, a configuration for sensing the temperature of the heat pump will be described in detail.

As shown in FIGS. 7 and 8, the heat pump may include the evaporator 132, the compressor 134, the condenser 136 and the expansion valve 138 which are connected with each other via the refrigerant pipe 660. The dryer accord-
ing to this embodiment may include at least one temperature sensor to sense the above temperature information. When sensing the exhausted refrigerant temperature of the condenser 136 and the drawn/exhausted refrigerant temperature of the evaporator 132, temperature sensors 628, 639a and 639b may be provided at a refrigerant outlet hole of the condenser 136 and refrigerant inlet and outlet holes of the evaporator 132, respectively. In addition, when sensing an exhaustion temperature of the compressor 134, a temperature sensor 642 may be further provided on an outlet hole of the compressor 134.

[0071] In other words, when sensing the exhausted refrigerant temperature of the condenser 136 and the drawn/exhausted refrigerant temperature of the evaporator 132, the locations of the temperature sensors 628, 639a, 639b and 642 may affect the temperature sensing. However, when sensing the refrigerant condensation temperature of the condenser 136 and the refrigerant evaporation temperature of the evaporator 132, the locations of the temperature sensors 628, 639a and 639b may be important. That is, to sense a phase change temperature of the refrigerant in the condenser 136 and the evaporator 132, it is preferable that temperature sensors 626 and 636 are provided along a line of the refrigerant line where the phase change is generated inside the condenser 136 and the evaporator 132.

[0072] In the meanwhile, the evaporator 132 may include a first temperature sensor 636 to sense the phase change temperature, that is, the evaporation temperature of the refrigerant in the evaporator 132 and the evaporator. The first temperature sensor 636 may be provided at a predetermined portion of the evaporator 132 to sense the phase change temperature of the refrigerant in the evaporator 132. For example, the first temperature sensor 636 may be provided at an almost center of the refrigerant line provided along the evaporator 132, that is, near a center of the length of the refrigerant line. This is because the phase change could be generated near the center portion of the length of the refrigerant line inside the evaporator 132. When the phase change of the refrigerant is generated near a refrigerant inlet hole or a refrigerant outlet hole along the refrigerant line of the evaporator 132, the refrigerant fails to heat-exchange with the air sufficiently and entire efficiency of the heat pump might be deteriorated. As a result, the phase change of the refrigerant may be generated near the center portion along the length of the refrigerant line of the condenser 132 and the second temperature sensor 626 may be provided adjacent to the center along the length of the refrigerant line of the condenser 136, to sense the phase change temperature of the refrigerant.

[0074] Here, when the evaporator 132 and the condenser 136 are conventional ones, a predetermined length refrigerant line and a plurality of heat-exchanger fins (not shown) connected with the refrigerant line to increase heat exchanging efficiency may be provided. In this case, a center area of the refrigerant line happens to be overlapped with the heat exchanger fins and it is difficult to install and secure the first and second temperature sensors 626 and 636 disadvantageously.

[0075] Because of that, it is preferable that the first and second temperature sensors 626 and 636 are installed on the refrigerant, with not overlapped with the heat exchanger fins. In other words, the first and second temperature sensors 626 and 636 may be installed at the heat exchanger fins comprising the evaporator 132 and the condenser 136 and at the refrigerant line passing the heat changer fins, with exposed to a predetermined portion of the heat exchanger fins. Even in this case, the installation locations of the first and second temperature sensors 626 and 636 may be adjacent to the center area of the refrigerant line.

[0076] In the meanwhile, the dryer according to the above embodiments includes the heat pump 130 as air heating/dehumidifying device. However, in an initial activation of the heat pump 130 after the activation of the dryer, the refrigerant fails to heat-exchange with the air in the evaporator 132 and all of the refrigerant could not be gaseous. Because of that, liquid refrigerant could be drawn into the compressor 134. If the liquid refrigerant might be drawn into the compressor, an error and damage could occur in the compressor. As a result, the dryer including the compressor may require a control method for preventing the damage to the compressor in the initial activation of the compressor. As follows, a control method according to an embodiment will be described in reference to corresponding drawings.

[0077] FIGS. 9 to 11 are graphs illustrating a control method for the dryer according to an embodiment. FIGS. 9 and 10 are graphs illustrating change of an activation velocity of the compressor based on the time. FIG. 11 is a graph illustrating change of an opening degree of the expansion valve based on the time. A horizontal axis shown in FIGS. 9 and 10 refers to the time (t) and a vertical axis refers to an activation velocity of the compressor. A horizontal axis shown in FIG. 11 refers to the time (t) and a vertical axis refers to an open level of the expansion valve.

[0078] In reference to FIG. 9, the control method according to the embodiment includes steps of increasing an activation velocity of the compressor to a target velocity and adjusting an opening degree of the expansion valve. In other words, the dryer the control method according to the embodiment which will be described can be applied to may be a dryer including a variable velocity compressor. In addition, the dryer may include the expansion valve and the expansion valve may be a type of an expansion valve capable of an opening degree, for example, a linear expansion valve (LEV). Since the activation velocity and/or the opening degree of the expansion valve can be adjusted, the above problem that the liquid refrigerant might be drawn into the compressor can be prevented, which will be described in detail as follows.
Here, the step of the increasing the activation velocity of the compressor to the target velocity may be performed for a first time band (T1). The first time band (T1) may start with the activation of the compressor according to the activation of the heat pump simultaneously. The heat pump may be activated according to a selected course when the dryer is put into operation. Because of that, the control method according to the embodiment may include a step of selecting at least one course to supply air or dried air, prior to the above steps.

When the activation velocity of the compressor is drastically increased from an initial stage of the activation, the liquid refrigerant might be drawn into the compressor as mentioned above. As a result, the activation velocity of the compressor according to this embodiment may be increased to the target velocity gradually, as shown in FIG. 9. In other words, the activation velocity of the compressor may be increased to the target velocity by a predetermined unit velocity gradually, not increased to the target velocity at one time. Because of that, the liquid refrigerant can be prevented from coming into the compressor.

Although FIG. 9 shows only the embodiment presenting that the activation velocity of the compressor is increased gradually, a control method according to another embodiment may increase the activation velocity of the compressor serially and FIG. 10 shows this embodiment presenting that the activation velocity of the compressor is increased serially.

In reference to FIG. 10, the activation velocity of the compressor may be increased to the target velocity along a predetermined curvature. In this case, the first time band (T1) is divided into a first half and a second half. A slope (k1) of the curvature in the first half may be set relatively larger than a slope (k2) of the curvature in the second half. In other words, the activation velocity of the compressor is increased by a relatively larger value in the first half of the first time band and the activation velocity of the compressor may be increased by a relatively small value, corresponding to the target activation velocity.

In the meanwhile, in case of increasing the activation velocity of the compressor in the first time band, the expansion valve may maintain a maximum open state. If the expansion valve is closed to a predetermined degree, not opened to a maximum degree, the quantity of the supplied refrigerant is reduced from the initial stage and the refrigerant cannot perform the condensing and heating of the moisture contained in the air smoothly. Because of that, the performance of the heat pump might be deteriorated. To solve the disadvantage, the control method according to this embodiment may control the expansion valve to maintain the maximum open degree and it may adjust the activation velocity of the compressor, to prevent the liquid refrigerant from being drawn into the compressor.

The expansion valve may be adjusted to be closed for a second time band (T2) following the first time band (T1). The first time band (T1) and the second time band (T2) may be in a serial order or a predetermined period of the second time band (T2) is overlapped with a predetermined period of the first time band (T1). For the second time band (T2), the open degree of the expansion valve is decreased gradually to close the expansion valve or it is adjusted to close the expansion valve. This is because stability of the compressor has to be maintained when the activation velocity of the compressor reaches the target velocity.

In other words, if the compressor is activated at the reached target velocity, the temperature of the compressor might be increased abnormally. If the temperature of the compressor is increased to a predetermined value or more abnormally, there might be damage or errors of the compressor. Because of that, the open degree of the expansion valve is decreased to close the expansion valve to drive the compressor stably and the quantity of the refrigerant is then decreased, only to prevent the temperature of the compressor from being increased too high.

As a result, the control unit may close the expansion valve gradually based on at least one piece of the temperature information relating to the heat pump. Here, the at least one piece of the temperature information relating to the heat pump may include at least one of the temperature of the refrigerant circulating the heat pump and the temperatures of the evaporator, compressor and condenser which compose the heat pump. For example, the at least one piece of the temperature information may include at least one of the temperature of the compressor, the temperature of the refrigerant drawn into the compressor, the temperature of the refrigerant exhausted from the compressor and the peripheral temperature of the compressor. Such temperature information may be collected from the various temperature sensors described in reference to FIGS. 7 and 8. As a result, temperature information relating to the compressor is sensed. When the sensed temperature increases to a predetermined value or more, the expansion valve may be controlled to be closed gradually.

In the meanwhile, the first time band and the second time band may be arranged in the serial order, not partially overlapped with each other. In other words, the control unit may control the expansion valve to be open to the maximum open degree in the first time band and the activation velocity of the compressor to be adjusted, to control the activation velocity of the compressor to reach a desired velocity. After that, in the second time band, the control unit may control the activation velocity of the compressor to be maintained at the target velocity and it may adjust the open degree of the expansion valve to activate the compressor stably.

Alternatively, at least a predetermined period of the second time band (T2) may be overlapped with a predetermined period of the first time band (T1) as mentioned above. For example, if the temperature of the compressor is increasing abnormally in the first time band, it is required to adjust the open degree of the expansion valve even in the first time band. In this case, after the step of opening the expansion valve to the maximum open degree for the first time band (T1), a step of closing the expansion valve by adjusting an open degree of the compressor may be further provided. In other words, when assuming that the step of adjusting the open degree of the expansion valve belongs to the second time band, it can be said that a time band for the step of adjusting both the activation velocity of the compressor and the open degree of the expansion valve is partially overlapped with the first and second time bands. However, it is preferable that the expansion valve is closed by adjusting the open degree a predetermined time after the first time band starts, to prevent the performance of the heat pump from deteriorating even if the open degree of the expansion valve is adjusted in the first time band (T1).

There might be a case that the temperature increase of the compressor cannot be prevented only by the adjusting of the expansion valve in the second time band. In this case, it is required to adjust the activation velocity of the compressor in the second time band. In other words, not maintaining the
activation velocity of the compressor in the second time band at the target velocity, the activation velocity of the compressor is adjusted to be lowered, for example. Even in this case, supposing that the step of adjusting the activation velocity of the compressor belongs to the first time band mentioned above, a time band in which the activation velocity of the compressor and the open degree of the expansion valve are adjusted together may be partially overlapped with the first and second time bands.

[0090] In the meanwhile, when the heat pump 130 is provided as mentioned above, the air heating and dehumidifying may be performed by the single device. At this time, more noise and vibration might be generated in comparison to the dryer including the conventional gas burner or electric heater. In other words, when the compressor 134 of the heat pump 130 is activated, noise and vibration of the dryer may be increased by the noise and vibration generated by the activation of the compressor. This increase of the noise and vibration might give an unpleasant feeling to the user of the dryer. Especially, the user might be reluctant to use the dryer in the middle of the night, because of the much noise and vibration. To reduce such the noise and vibration of the dryer, the activation noise and vibration of the compressor has to be reduced.

[0091] For that, when the dryer includes the heat pump, the heat pump may include a variable velocity type compressor. When the dryer is activated based on the user’s selection for reducing the noise and vibration or in the middle of the night, the activation velocity of the compressor may be adjusted to reduce the noise and vibration, for example. As follows, a control method capable of reducing the noise and vibration of the dryer including the variable velocity type compressor will be described in detail.

[0092] FIG. 12 is a flow chart illustrating a control method of the dryer according to another embodiment.

[0093] In reference to FIG. 12, the control method of the dryer may include steps of: identifying a low noise activation condition of the dryer (S1210); and adjusting an activation velocity of a variable velocity type compressor based on the low noisy activation condition (S1230).

[0094] First of all, when the user selects one of courses provided in the dryer, the control unit provided in the dryer may identify ‘a low noisy activation condition’ of the dryer (S1210). In other words, when the user selects one of the courses, the control unit may identify a low noisy activation condition during the implementation of the selected course.

[0095] Here, ‘the low noisy activation condition’ refers to a condition set to reduce more noise when the dryer is activated, compared with a standard course (or a normal course). Such the condition may be set by the user or it may be set by the control unit automatically, which will be described as follows.

[0096] If the user tries to input the low noisy activation condition manually, an auxiliary low vibration and/or low noise course may be provided in the dryer or the user may select ‘a low noise function’ additionally after selecting a course. As a result, when the user selects a predetermined course such as the low vibration and/or low noise course or a predetermined mode such as ‘the low noise function’, the low noisy activation condition may be input.

[0097] In the meanwhile, when the low noisy activation condition is automatically input by the control unit, a predetermined time band (hereinafter, referenced to as ‘a low noisy time band’) in which the low noisy activation condition is preset may be input and stored in the control unit. For example, 7 p.m.–7 a.m. may be set in the low noisy time band. When the activation time band of the dryer is included in the low noisy time band, the control unit may input the low noisy activation condition automatically. Here, the low noisy time band may be input and stored in the dryer in advance, to be output. In addition, the low noisy time band may be adjusted by the user’s selection properly.

[0098] In the meanwhile, if the activation time band of the dryer is included in the low noisy activation time band, an entire period of the activation time band may be overlapped with the low noisy activation time band or a predetermined period of the activation time band may be overlapped with the low noisy activation time band. If the entire period of the activation time band is overlapped with the low noisy activation time band which is the former case, the control unit may input the low noisy activation condition automatically.

[0099] However, if the predetermined period of the activation time band of the dryer is overlapped with the low noisy time band, the activation condition may be set different based on the overlapped time band. For example, if the activation time band of the compressor is included in the predetermined period of the activation time band of the dryer which is overlapped with the low noisy time band, the control unit may set the low noisy activation condition. However, if the activation time band of the compressor is not provided in the predetermined period of the activation time band of the dryer which is overlapped with the low noisy time band, the control unit may not set the low noisy activation condition. In other words, only when the activation time band of the compressor is included in the low noisy time band, the control unit may set the low noisy activation condition. This is because the activation noise of the compressor affects the noise of the dryer most.

[0100] FIG. 13 shows that the activation time band of the compressor is overlapped with a predetermined period of the low noisy time band, if the dryer is activated.

[0101] In reference to FIG. 13, the activation of the compressor starts at a time period which does not belong to the low noisy time band (T1) and it enters into the low noisy time band (T3) after that. This case may refer to ‘α’. In this case (α), the compressor is activated at a first velocity (Hz1) in a time band which does not belong to the low noisy time band (T3) and it is activated at a second velocity (Hz2) reduced from the first velocity in a time band which enters into the low noisy time band (T3). Here, the activation of the compressor may start at a time (T1) belonging to the low noisy time band (T3) and it gets out of the low noisy time band (T3). This case may refer to ‘β’. In this case (β), the compressor is activated at the second velocity (Hz2) in a time belonging to the low noisy time band (T3) and the velocity of
the compressor is adjusted to be the first velocity (the normal velocity, Hz1) in a time out of the low noisy time band (T3).

[0102] In the meanwhile, after identifying the low noisy activation condition of the dryer, the control unit may adjust the activation velocity of the variable velocity type compressor based on the identified activation condition (S1230).

[0103] The reason why the activation velocity of the compressor is adjusted is that the noise and vibration generated by the activation of the compressor has to be reduced. Because of that, the control unit may control the noise and vibration by reducing the activation velocity of the compressor. An activation velocity of the compressor when the dryer is activated according to 'Standard course (or Normal course) in the day time may be defined as 'normal velocity (Hz1)'. When the low noisy activation condition is set, the control unit may control the compressor to be activated at an activation velocity (Hz2) which is lower than the normal velocity. For example, the control unit may activate the compressor at a predetermined rpm which is corresponding to approximately 40%–60% of a normal rpm.

[0104] When the low noisy activation condition is set, the control unit may activate the compressor at a predetermined velocity allowing the activation noise of the compressor to be a predetermined db or less. For example, the control unit may adjust the activation velocity of the compressor for the noise of the compressor to be 40–60 db or less.

[0105] FIG. 14 is a graph illustrating noise distribution based on the activation velocity of the compressor. A horizontal axis refers to the activation velocity (Hz) of the compressor and a vertical axis refers to a noise (db) of the compressor.

[0106] In reference to FIG. 14, the noise of the compressor is approximately 63 db, if the activation velocity of the compressor is approximately 90 Hz. When the activation velocity of the compressor is lowered to be approximately 30 Hz, the noise of the compressor is approximately 48 db. For example, in case the low noisy activation condition is not input by the user or it is not input by the control unit automatically when the normal velocity (Hz1) of the compressor is approximately 90 Hz, the compressor may be activated at the normal velocity.

[0107] If the low noisy activation condition is input by the user or automatically input by the control unit, the compressor may be activated at the second velocity (Hz2), for example, 30 Hz, to reduce the noise. In this case, the control unit may cut a proportion of the activation velocity of the compressor to the normal velocity to a predetermined percentage and it may activate the compressor at the reduced velocity, as mentioned above. Alternatively, the control unit may activate the compressor for the noise of the compressor to be a predetermined value or less, as mentioned above.

[0108] In the meanwhile, the dryer is embodied to explain the embodiments and the control method according to the above embodiments can be applied to the washing machine having a drying function, by extension, even to the clothes treatment apparatus including the heat pump to dry clothes.

[0109] Therefore, the control method according to the present invention may prevent the liquid refrigerant from being drawn into the compressor in the initial activation of the compressor. Because of that, the compressor may be operated stably.

[0110] Furthermore, the control method according to the present invention may control the quantity of the refrigerant based on the temperature information relating to the compressor. Because of that, the overheating of the compressor may be prevented.

[0111] Still further, the control method according to the present invention may adjust the activation velocity of the variable velocity type compressor. Because of that, the noise and vibration generated in the compressor may be reduced remarkably.

[0112] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the inventions. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A control method of a dryer comprising a heat pump including a variable velocity type compressor, the control method comprising steps of:
   selecting at least one course set to supply air or dried air;
   increasing an activation velocity of the compressor to a target velocity, as the selected course is implemented;
   and
   adjusting an open degree of an expansion valve provided in the heat pump.

2. The control method of the dryer as claimed in claim 1, wherein the step of increasing the activation velocity of the compressor to the target velocity is performed for a first time band.

3. The control method of the dryer as claimed in claim 2, wherein an open degree of the expansion valve is maintained at a maximum value for the first time band.

4. The control method of the dryer as claimed in claim 2, further comprising steps of:
   opening the expansion valve at a maximum degree for the first time band; and
   closing the expansion valve by adjusting the open degree of the expansion valve for the first time band.

5. The control method of the dryer as claimed in claim 4, wherein the expansion valve is closed by adjusting the open degree of the expansion valve for a predetermined time after the first time band starts.

6. The control method of the dryer as claimed in claim 2, wherein the activation velocity of the compressor is gradually increased for the first time band.

7. The control method of the dryer as claimed in claim 2, wherein the activation velocity of the compressor is gradually increased for the first time band.

8. The control method of the dryer as claimed in claim 7, wherein the activation velocity of the compressor is serially increased along a predetermined curvature.

9. The control method of the dryer as claimed in claim 8, wherein a slope of the curvature in a first half of the first time band is larger than a slope of the curvature in a second half of the first time band.

10. The control method of the dryer as claimed in claim 1, wherein the step of adjusting the open degree of the expansion valve is performed for a second time band.

11. The control method of the dryer as claimed in claim 10, wherein the expansion valve is closed gradually.

12. The control method of the dryer as claimed in claim 11, wherein the expansion valve is closed based on at least one piece of temperature information relating to the heat pump.
13. The control method of the dryer as claimed in claim 12, wherein the temperature information relating to the heat pump comprises at least one of a temperature of a refrigerant circulating the heat pump and a temperature of an evaporator, a temperature of a compressor and a temperature of a condenser which are provided in the heat pump.

14. The control method of the dryer as claimed in claim 12, wherein the expansion valve is closed gradually when the at least one piece of the temperature information relating to the heat pump is increased to a preset value or more.

15. The control method of the dryer as claimed in claim 10, wherein an activation velocity of the compressor is maintained to be the target velocity for the second time band.

16. The control method of the dryer as claimed in claim 10, wherein an activation velocity of the compressor is adjusted for the second time band.

17. The control method of the dryer as claimed in claim 1, further comprising steps of:
   identifying a low noisy activation condition of the dryer while a selected course is implemented; and
   adjusting an activation velocity of the compressor based on the low noisy activation condition.

18. The control method of the dryer as claimed in claim 17, wherein the low noisy activation condition of the dryer is set manually or automatically.

19. The control method of the dryer as claimed in claim 17, wherein the low noisy activation condition of the dryer is set based on a user’s selection or an activation time band of the dryer.

20. The control method of the dryer as claimed in claim 19, wherein the low noisy activation condition of the dryer is set when the user selects a predetermined course or a predetermined mode.

21. The control method of the dryer as claimed in claim 19, wherein the low noisy activation condition of the dryer is set when an activation time band of the dryer belongs to a predetermined time band.

22. The control method of the dryer as claimed in claim 21, wherein the low noisy activation condition of the dryer is set when an activation time band of a variable velocity type compressor provided in the dryer belongs to a predetermined time band.

23. The control method of the dryer as claimed in claim 17, wherein the step of adjusting the activation velocity of the variable velocity type compressor activates the variable velocity type compressor at a predetermined velocity which is lower than a normal velocity of the compressor.

24. The control method of the dryer as claimed in claim 17, wherein the step of adjusting the activation velocity of the variable velocity type compressor activates the variable velocity type compressor at a predetermined velocity which allows noise generated in the compressor to be a preset reference value or lower.

25. A dryer comprising:
   a user operational part configured to receive at least one piece of drying information;
   a control unit configured to generate an operation signal based on the drying information input via the user operational part;
   a heat pump activated based on the operation signal generated in the control unit, the heat pump comprising a compressor and an expansion valve,
   wherein an activation velocity of the compressor is increased to a preset target velocity based on the operation signal for a first time band and an open degree of the expansion valve is adjusted based on the operation signal for a second time band which is in a serial order with the first time band

26. The dryer as claimed in claim 25, wherein the second time band is partially overlapped with the first time band.

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