A motor cap has a plurality of holes in the top of the cap for the entry of refrigerant into the suction plenum. The holes are sized and located to create a tortuous path for a stream of refrigerant to enter the compression chamber. The refrigerant stream is broken into multiple streams and any liquid refrigerant is encouraged to flash to vapor. Any oil that is brought from the sump at startup by boiling liquid refrigerant is likewise encouraged to remain on the motor cap and drain back to the sump while the liquid refrigerant flashes to vapor.
MOTOR CAP FOR A COMPRESSOR

BACKGROUND

The application generally relates to motor caps for hermetic compressors.

Aftermarket compressors (compressors installed into systems to replace a failed compressor) typically fail at a rate 3 to 4 times higher than original equipment manufacturer (OEM) initial installations. The high failure rate can be due to a variety of factors that can be present or occur in field installations. Some of the factors contributing to a high failure rate can include the presence of acids in the system during the installation process, the miswiring of the aftermarket compressor, overcharging the system with refrigerant during the installation process, or poor brazing techniques when installing the aftermarket compressor.

One problem for compressors, whether an OEM compressor or an aftermarket compressor, is the entry of liquid refrigerant or oil into the compression mechanism, which can damage the compressor and shorten the compressor’s operational life.

Thus, what is needed is a motor cap for a compressor that can restrict liquid refrigerant from entering directly into the compression mechanism of the compressor.

SUMMARY

The present invention is directed to a compressor including a shell having an enclosed space, a compression mechanism positioned within the enclosed space of the shell, and a motor positioned within the enclosed space of the shell and connected to the compression mechanism by a shaft to power the compression mechanism. The compressor also includes a motor cap positioned on the motor opposite the compression mechanism. The motor cap has a top surface and a sidewall extending from the top surface toward the motor. The top surface and sidewall defining a plenum between the motor and the motor cap to store refrigerant. The top surface of the motor cap includes a plurality of holes. The plurality of holes permit passage of refrigerant between the enclosed space and the plenum.

In the present application, the motor cap has a plurality of small holes in the top of the cap rather than the typical large hole adjacent to the suction port to the compressor. The holes are sized and located in a manner that creates a tortuous path for a stream of refrigerant, which may include liquid refrigerant, to enter the compression chamber. Any liquid refrigerant in the stream is broken into multiple streams and encouraged to flash to vapor. Any oil that is brought from the sump at startup by boiling liquid refrigerant is likewise encouraged to remain on the motor cap and drain back to the sump while the liquid refrigerant flashes to vapor.

One advantage of the present application is that the total flow area and placement of the holes allows motor cooling by the vapor with a sufficiently low pressure drop that compressor efficiency is insignificantly effected.

Other features and advantages of the present application will be apparent from the following more detailed description of the embodiments, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an embodiment of a compressor.

FIG. 2 schematically shows an embodiment of a vapor compression system.

FIG. 3 schematically shows another embodiment of a vapor compression system.

FIG. 4 shows an embodiment of a motor cap mounted in a compressor housing.

FIGS. 5 and 6 show front and rear perspective views of an embodiment of a motor cap.

FIG. 7 shows a top view of an embodiment of a motor cap.

FIG. 8 shows a front view of the motor cap of FIG. 7.

FIG. 9 shows a cross-sectional view of the motor cap of FIG. 7 taken along line 9-9 of FIG. 7.

FIG. 10 shows a bottom view of the motor cap of FIG. 7.

FIG. 11 shows a rear perspective view of an embodiment of a motor cap.

FIG. 12 shows a top view of an embodiment of a motor cap.

FIG. 13 shows a front view of the motor cap of FIG. 12.

FIG. 14 shows a cross-sectional view of the motor cap of FIG. 12 taken along line 14-14 of FIG. 12.

FIG. 15 shows a bottom view of the motor cap of FIG. 12.

FIG. 16 show a front view of the motor cap of FIG. 12 with a connected attenuator.

FIG. 17 shows an embodiment of a suction filter for the motor cap of FIG. 12.

Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

DETAILED DESCRIPTION OF THE EMBODIMENTS

FIG. 1 shows an embodiment of a reciprocating compressor. However, in other embodiments, the compressor can be any suitable type of hermetic or semi-hermetic compressor including, but not limited to, a rotary compressor, screw compressor, swag link compressor, scroll compressor, spool compressor, centrifugal compressor, or turbine compressor.

In FIG. 1, compressor 2 can have a suction port or fitting 14 that can be in fluid communication with an evaporator of a vapor compression system upon the connection of a suction line or conduit from the evaporator to the suction port 14. The suction port 14 can be in fluid communication with a suction plenum 12 through one or more openings in a motor cap 13. Refrigerant gas from the evaporator can enter the compressor 2 through the suction port 14 and then flow to the suction plenum 12 before being compressed. In one embodi-
ment, the refrigerant gas from the suction port 14 can also fill the interior space of the compressor housing before flowing to the suction plenum 12.

[0029] The compressor 2 can use an electrical motor 18. As shown in FIG. 1, motor 18 is an induction motor having a stator 20 and a rotor 22. However, in other embodiments, any other suitable type of electrical motor may be used including, but not limited to, a switched reluctance (SR) motor or an electronically commutated permanent magnet motor (ECM). A shaft assembly 24 extends through the rotor 22. The bottom end 26 of the shaft assembly 24 extends into an oil sump 405 and includes a series of apertures 27. Connected to the shaft assembly 24 below the motor is a compression device 30, such as a piston assembly as shown in FIG. 1. In FIG. 1, the piston assembly 30 has two pistons. A connecting rod 32 is connected to a piston head 34, which moves back and forth within a cylinder 36. The cylinder 36 includes a gas inlet port 38 and a gas discharge port 40. Associated with these ports 38, 40 are associated suction valves and discharge valves. The gas inlet port 38 is connected to an intake tube 54, which is in fluid communication with the suction plenum 12.

[0030] The motor 18 can be activated by a signal in response to the satisfaction of a predetermined condition, for example, an electrical signal from a thermostat when a preset temperature threshold is reached. While a thermostat is used as an example, it should be known that any type of device or signal may be used to activate the compressor 2. When the compressor 2 is activated, electricity is supplied to the stator 20, and the windings in the stator 20 cause the rotor 22 to rotate. Rotation of the rotor 22 causes the shaft assembly 24 to turn. When the shaft assembly 24 is turning, oil sump fluid in the oil sump 405 enters the apertures 27 in the bottom end 26 of the shaft and then moves upward through and along the shaft 24 to lubricate the moving parts of the compressor 2.

[0031] Rotation of the rotor 22 also causes reciprocating motion of the piston assembly 30. As the assembly 30 moves, the piston head 34 moves away from gas inlet port 38, the suction valve opens and refrigerant fluid is introduced into an expanding cylinder 36 volume. The gas is pulled from the suction plenum 12 through the intake tube 54 to the gas inlet port 38 where the gas passes through the suction valve and is introduced into the cylinder 36. When the piston assembly 30 reaches a first end (or top) of its stroke, shown by movement of the piston head 34 to the right side of the cylinder 36 of FIG. 1, the suction valve closes. The piston head 34 then compresses the refrigerant gas by reducing the cylinder 36 volume. When the piston assembly 30 moves to a second end (or bottom) of its stroke, shown by movement of piston head 34 to the left side of cylinder 36 of FIG. 1, a discharge valve is opened and the compressed refrigerant gas is expelled through the gas discharge port 40. The compressed refrigerant gas flows from the gas discharge port 40 into a muffler 50 then through an exhaust or discharge tube 52 to a discharge port or fitting. The discharge port can be in fluid communication with a condenser upon the connection of a discharge line or conduit from the condenser to the discharge port.

[0032] The compressor 2 may be connected to a vapor compression system that is included in a heating, ventilation and air conditioning (HVAC) system, refrigeration system, chilled liquid system or other suitable type of system. FIGS. 2 and 3 show different embodiments of vapor compression systems. In FIG. 2, vapor compression system 300 includes the compressor 2, a condenser 304, and an evaporator 306, while in FIG. 3, vapor compression system 300 includes the compressor 2, a reversing valve 350, an indoor unit 354 and an outdoor unit 352.

[0033] The vapor compression system 300 can be operated as an air conditioning system, where the evaporator 306 is located inside a structure or indoors, i.e., the evaporator is part of indoor unit 354, to provide cooling to the air in the structure and the condenser 304 is located outside a structure or outdoors, i.e., the condenser is part of outdoor unit 352, to discharge heat to the outdoor air. The vapor compression system 300 can also be operated as a heat pump system, i.e., a system that can provide both heating and cooling to the air in the structure, with the inclusion of the reversing valve 350 to control and direct the flow of refrigerant from the compressor 2. When the heat pump system is operated in an air conditioning mode, the reversing valve 350 is controlled to provide for refrigerant flow as described above for an air conditioning system. However, when the heat pump system is operated in a heating mode, the reversing valve 350 is controlled to provide for the flow of refrigerant in the opposite direction from the air conditioning mode. When operating in the heating mode, the condenser 304 is located inside a structure or outdoors, i.e., the condenser is part of indoor unit 354, to provide heating to the air in the structure and the evaporator 306 is located outside a structure or outdoors, i.e., the evaporator is part of outdoor unit 352, to absorb heat from the outdoor air.

[0034] In vapor compression system 300, whether operated as a heat pump or as an air conditioner, the compressor 2 is driven by the motor 18 that is powered by a motor drive 104. The motor drive 104 receives AC power having a particular fixed line voltage and fixed line frequency from AC power source 102 and provides power to the motor 18. In another embodiment, the motor 18 can be powered directly by the AC power source 102. The motor 18 used in the system 300 can be any suitable type of motor that can be powered by a motor drive 104.

[0035] Referring back to FIGS. 2 and 3, the compressor 2 compresses a refrigerant vapor and delivers the vapor to the condenser 304 through a discharge line (and the reversing valve 350 if configured as a heat pump). Some examples of refrigerants that may be used in vapor compression system 300 are: hydrofluorocarbon (HFC) based refrigerants, for example, R-410A, R-407C, R-404A, R-134a and R-32 (a component of R410A and R407C); hydrofluoro olefin (HFO) refrigerants, also known as “unsaturated HFCs,” such as R1234yf; inorganic refrigerants like ammonia (NH3), R-717 and carbon dioxide (CO2), R-744; hydrocarbon (HC) based refrigerants such as propane (R-290), isobutane (R-600a) or propene (R-1270), or any other suitable type of refrigerant. The refrigerant vapor delivered by the compressor 2 to the condenser 304 enters into a heat exchange relationship with a process fluid, e.g., air or water, and undergoes a phase change to a refrigerant liquid as a result of the heat exchange relationship with the process fluid. The condensed liquid refrigerant from the condenser 304 flows through an expansion device to the evaporator 306.

[0036] The condensed liquid refrigerant delivered to the evaporator 306 enters into a heat exchange relationship with another process fluid, e.g., air or water, and undergoes a phase change to a refrigerant vapor as a result of the heat exchange relationship with the process fluid. The vapor refrigerant in the evaporator 306 exits the evaporator 306 and returns to the compressor 2 by a suction line (and the reversing valve...
arrangement 350 if configured as a heat pump) to complete the cycle. In other embodiments, any suitable configuration of the condenser 304 and the evaporator 306 can be used in the system 300, provided that the appropriate phase change of the refrigerant in the condenser 304 and evaporator 306 is obtained. For example, if air is used as the process fluid to exchange heat with the refrigerant in the condenser 304 or the evaporator 306, then one or more fans can be used to provide the necessary airflow through the condenser 304 or evaporator 306. The motors for the one or more fans may be powered directly from the AC power source 102 or a motor drive, such as motor drive 104.

[0037] FIG. 4 shows an embodiment of a motor cap. The motor cap 13 can be mounted within a shell 98 of the compressor 2. The motor cap 13 can be mounted on the motor 18 and stabilized in the shell 98 by a spring or tensioning device 96 mounted in a depression 95 of the motor cap 13. A suction fitting 80 can be mounted or fastened within shell 98 to permit refrigerant to enter the compressor 2. The suction fitting 80 can have a first portion 82 that is substantially cylindrical and a second portion 84 that expands in diameter from the first portion 82. The second portion 84 can be attached in the compressor housing 98 to form the hermetic seal for the compressor 2. The second portion 84 can have louvers 86 to direct refrigerant flow once it enters compressor 2 and a suction filter 88 to remove debris from the refrigerant flowing through the compressor.

[0038] The refrigerant that enters the compressor 2 through suction fitting 80 can then fill the internal volume of the compressor shell 98 and be used to cool the motor by flowing through holes 200 in the top surface 202 of the motor cap. The refrigerator then leaves the motor cap 13 through a sealed passageway and flows to the suction valve of the compression mechanism or device 30. The holes 200 in the motor cap 13 are used to disrupt the flow of (or provide a tortuous path for) the refrigerant entering the motor cap 13. The interrupted flow is then used to remove any entrained oil or liquid refrigerant from the refrigerator flow before the oil or liquid refrigerant enters the compression mechanism 30. Instead of providing a disrupted flow, the holes 200 can provide numerous surfaces for entrained liquids to coalesce and then the coalesced liquids can either flash into refrigerant vapor (if refrigerant liquid) or drain back to the oil sump 405 (if oil). In addition, the holes 200 in the motor cap 13 may also be used to filter any large debris in the refrigerant flow and prevent that debris from entering the motor 18 or compression mechanism 30.

[0039] FIGS. 5-15 show different views of different embodiments of the motor caps. The motor cap 13 can have holes 200 positioned on approximately 25-75% of the top surface 202 of the motor cap 13. In other embodiments, the holes 200 can be positioned over a greater or lesser percentage of the top surface 202 of the motor cap 13 so long as an appropriate amount of refrigerant enters the suction plenum 12.

[0040] In one embodiment, the motor cap 13 can have a first portion 204 and a second portion 206. The holes 200 can be positioned or located on the second portion 206 of the motor cap 13. The first portion 204 can have one or more openings 208 for intake tubes 54 (see FIG. 16) to be connected that provide a passageway for refrigerant between the suction plenum 12 and the compression device 30. A minor axis 210 of the motor cap 13 through a center point 212 of the depression 95 can be used as a divider between the first portion 204 and the second portion 206. However, any suitable location or configuration for the divider between the first portion 204 and the second portion 206 can be used (see e.g., FIG. 11, where the divider is associated with a line parallel to the minor axis 210).

[0041] The holes 200 can be arranged in a patterned configuration where the distances between holes 200 and the locations of the holes 200 are consistent, i.e., the same predetermined distance(s) and location placement(s) are used in the configuration. In another embodiment, the holes 200 can have a more random configuration where the distances between holes 200 and the locations of the holes 200 are not consistent, i.e., multiple predetermined distances and location placements can be used in a non-structured manner. In one exemplary embodiment, the holes 200 can be arranged in the shape of an arc, square, rectangle, triangle, circle, oval, trapezoid or any other suitable geometric shape. In addition, the holes 200 can be arranged using one or more geometric shapes, either symmetrically or asymmetrically placed about a major axis 214 of the motor cap 13 through the center point 212 of the depression 95. The number of holes 200 in the top surface 202 of the motor cap 13 can vary between 2 holes and 200 or more holes depending on the size of the motor cap 13 and the diameter of the holes 200.

[0042] The holes 200 can be arranged in a patterned configuration having a plurality of rows and columns. In the embodiments of FIGS. 5-11, the rows and columns can be arranged such that the holes 200 in one row or column are positioned between the holes 200 in the adjacent or neighboring rows or columns. In other words, the holes 200 in adjacent rows or columns are offset from one another by 45 degrees (see e.g., FIG. 7). In the embodiments of FIGS. 12-15, the rows and columns can be arranged such that the holes 200 in one row or column are offset the holes 200 in the adjacent or neighboring rows or columns by 60 degrees (see e.g., FIG. 12). In other embodiments, the offset angle between holes in adjacent rows or columns can be greater than or less than 45 degrees or 60 degrees depending on the number and size of holes 200. The number of holes 200 in a row or column can vary between 1 hole and 20 or more holes. In the embodiment shown in FIG. 7, the maximum number of holes per column is 10 and the maximum number of holes per row is 5. In the embodiment shown in FIG. 12, the maximum number of holes per column is 2 and the maximum number of holes per row is 1.

[0043] As shown in FIG. 7, the predetermined spacing between holes in the same row or column is shown by dimension B and the predetermined spacing between holes in adjacent rows or columns is shown by dimension A. In one embodiment, dimension B can range between about 0.15 inches and about 0.65 inches and can be 0.40 inches and dimension A can range between about 0.10 inches and 0.30 inches and can be 0.20 inches.

[0044] As shown in FIG. 12, the predetermined spacing between holes in the same row or column is shown by dimension B and the predetermined spacing between holes in adjacent rows or columns is shown by dimension A. In one embodiment, dimension B can range between about 2.25 inches and about 2.65 inches and can be 2.45 inches and dimension A can range between about 0.50 inches and 1.00 inches and can be 0.75 inches.

[0045] In one embodiment, the holes 200 can have a circular shape. However, in other embodiments, the holes 200 can use one or more suitable geometric shapes including, but not limited to, square, rectangle, triangle, circle, oval, hexagon and octagon. The holes 200 can use a constant predetermined
diameter or size, i.e., each hole 200 has the same diameter or size. However, in another embodiment, the holes 200 can have different predetermined diameters or sizes that can be arranged in particular configurations to obtain particular characteristics such as improved flow, noise control, etc. The diameter(s) for the holes 200 shown in FIGS. 5-11 can range between about 0.05 inches and about 0.30 inches and can be 0.125 inches and the diameter(s) for the holes 200 shown in FIGS. 12-15 can range between about 1.00 inches and about 1.50 inches and can be 1.25 inches.

The motor cap 13 can also include numerous other features needed for the installation of the motor cap 13 and the operation of the compressor 2. For example, the motor cap 12 can include openings 224 (see FIG. 8) for electrical connections. In addition, the motor cap 13 can include the depression or indentation 95 to hold a spring or another stabilizing device 96 to hold the motor 18 and compression mechanism 30 in position in the compressor shell 98 and to prevent vibrations in the shell or housing 98 from being transferred to the motor 18 and compression mechanism.

As shown in FIG. 16, intake tubes 54 can be connected to openings 208 in motor cap 13 to provide a passage for refrigerant between suction plenum 12 and compression device 30. An attenuator assembly 222 can be connected between the suction plenum 12 and compression device 30 to provide noise and/or vibration attenuation and reduction. In one embodiment, the number of openings 208 in motor cap 13 and connected intake tubes 54 can correspond to the number of compression chambers in compression device 30.

As shown in FIG. 4, the suction fitting 80 can include a filter 88 to remove debris and contaminants from the refrigerant flow prior to the refrigerant entering the shell 98. However, in other embodiments, the suction fitting 80 can be a cylindrical tube welded in the shell 98 without any filtering capabilities. To prevent debris and contaminants from entering the suction plenum 12 (and possibly the motor 18 or compression device 30), a filtering device 250 (see FIG. 17) can be placed over the holes 200 in the motor cap 13 to prevent any debris or contaminants from entering the suction plenum 12. In one embodiment, the filtering device can be a stainless steel mesh, however any suitable filtering mechanism or technique can be used.

As would be appreciated by those of ordinary skill in the pertinent art, the functions of several elements of the present application may, in alternative embodiments, be carried out by fewer elements, or a single element. Similarly, in some embodiments, any functional element may perform fewer, or different, operations than those described with respect to the exemplary embodiment. Also, functional elements shown as distinct in the drawings may be incorporated within other functional elements, separated in different hardware or distributed in various ways in a particular implementation. Further, relative size and location are merely somewhat schematic and it is understood that not only the same but many other embodiments could have varying depictions.

All relative descriptions herein such as above, below, left, right, up, and down are with reference to the Figures, and not meant in a limiting sense. Relative descriptions such as inner and outward are with reference to being a direction toward the interior of a compressor shell whereas outer and outward are a direction away from the compressor. The shown assemblies can be understood as providing exemplary features of varying detail of certain embodiments, and therefore, components, modules, elements, and/or aspects of the drawings can be otherwise added to, combined, interconnected, sequenced, separated, interchanged, positioned, and/or rearranged without materially departing from the disclosed systems or methods. Additionally, the shapes and sizes of components are also exemplary and unless otherwise specified, can be altered without materially affecting or limiting the disclosed technology.

It is important to note that the construction and arrangement of the present application as shown in the various exemplary embodiments is demonstrative only. Although only a few embodiments have been described in detail in this application, those who review this application can readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters (e.g., temperatures, pressures, etc.), mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter described in the application. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the position of elements may be reversed or otherwise varied, and the nature or number of discrete elements or positions may be altered or varied. Accordingly, all such modifications are intended to be included within the scope of the present application. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. In the claims, any means-plus-function clause is intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Other substitutions, modifications, changes and omissions may be made in the design, operating conditions and arrangement of the exemplary embodiments without departing from the scope of the present application. Accordingly, the present application is not limited to a particular embodiment, but extends to various modifications that nevertheless fall within the scope of the appended claims.

Furthermore, in an effort to provide a concise description of the exemplary embodiments, all features of an actual implementation may not have been described (i.e., those unrelated to the presently contemplated best mode of carrying out the invention, or those unrelated to enabling the invention). It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation specific decisions may be made. Such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure, without undue experimentation.

What is claimed is:

1. A compressor comprising:
a shell having an enclosed space;
a compression mechanism positioned within the enclosed space of the shell;
a motor positioned within the enclosed space of the shell and connected to the compression mechanism by a shaft to power the compression mechanism;
a motor cap positioned on the motor opposite the compression mechanism, the motor cap comprising a top surface and a sidewall extending from the top surface toward the motor, the top surface and sidewall defining a plenum between the motor and the motor cap to store refrigerant; and
the top surface of the motor cap comprising a plurality of holes, the plurality of holes permitting passage of refrigerant between the enclosed space and the plenum.