A discharge valve is adapted to a linear compressor which is elastically supported in an axial direction by a discharge valve spring and which opens/closes a compression space defined between a cylinder and a piston, the discharge valve comprising: a body made from a metal material; and a coating layer made from a plastic material to wrap the body. The linear compressor provided with such a discharge valve is ensured with a satisfactory level of strength with less use of materials.
DISCHARGE VALVE FOR LINEAR COMPRESSOR

TECHNICAL FIELD

[0001] The present invention relates in general to a discharge valve for a linear compressor, and more particularly, to a discharge valve for a linear compressor, strength of which stays or is secured at a satisfactory level with less use of materials.

BACKGROUND ART

[0002] In general, a reciprocating compressor is designed to form a compression space to/from which an operation gas is sucked/discharged between a piston and a cylinder, and the piston linearly reciprocates inside the cylinder to compress refrigerants.

[0003] Most reciprocating compressors today have a component like a crankshaft to convert a rotation force of a drive motor into a linear reciprocating drive force for the piston, but a problem arises in a great mechanical loss by such motion conversion. To solve the problem, development of linear compressors is still under progress.

[0004] Linear compressors have a piston that is connected directly to a linearly reciprocating linear motor, so there is no mechanical loss by the motion conversion, thereby not only enhancing compression efficiency but also simplifying the overall structure. Moreover, since their operation is controlled by controlling an input power to a linear motor, they are much less noisy as compared to other compressors, which is why linear compressors are widely used in indoor home appliances such as a refrigerator.

[0005] FIG. 1 illustrates one example of a linear compressor in accordance with a prior art. The linear compressor has an elastically supported structure inside a shell (not shown), the structure including a frame 1, a cylinder 2, a piston 3, a suction valve 4, a discharge valve assembly 5, a linear motor 6, a motor cover 7, a supporter 8, a body cover 9, main springs S1 and S2, a muffler assembly 10, and a mass member 20.

[0006] The cylinder 2 is integrally fixed to the frame 1, and the discharge assembly 5 constituted by a discharge valve 5a, a discharge cap 5b, and a discharge valve spring 5c is installed to one end of the cylinder 2. The piston 3 is inserted into the cylinder 2, and the suction valve 4 which is very thin is installed to open or close a suction port 3a of the piston 2.

[0007] The linear motor 6 is installed in a manner that a permanent magnet 6c linearly reciprocates while maintaining the air-gap between an inner stator 6a and an outer stator 6b. To be more specific, the permanent magnet 6c is connected to the piston 3 with a connecting member 6d, and an interactive electromagnetic force between the inner stator 6a, the outer stator 6b, and the permanent magnet 6c makes the permanent magnet 6c linearly reciprocating to actuate the piston 3.

[0008] The motor cover 7 supports the outer stator 6b in an axial direction to fix the outer stator 6b and is bolted to the frame 1. The body cover 9 is coupled to the motor cover 7, and between the motor cover 7 and the body cover 9 there is the supporter 8 that is connected to the other end of the piston 3 while being elastically supported in an axial direction by the main springs S1 and S2. The muffler assembly 10 for sucking in refrigerant is also fastened to the supporter 8.

[0009] Here, the main springs S1 and S2 include four front springs S1 and four rear springs S2 that are arranged in horizontally and vertically symmetrical positions about the supporter 8. As the linear motor 6 starts running, the front springs S1 and the rear springs S2 move in opposite directions and buff the piston 3 and the supporter 8. In addition to these springs, the refrigerant in the compression space P functions as sort of a gas spring to buff the piston 3 and the supporter 8.

[0010] Therefore, when the linear motor 6 starts running, the piston and the muffler assembly 10 connected to it move in a linear reciprocating direction, and with the varying pressure in the compression space P the operation of the suction valve 4 and the discharge valve assembly 5 are automatically regulated. Under this mechanism, the refrigerant flows via a suction pipe on the side of the shell, an opening of the body cover 9, the muffler assembly 10, and suction ports 3a of the piston 3 until it is sucked in the compression space P and compressed. The compressed refrigerant then escapes to the outside through the discharge cap 5b, the loop pipe and an outlet duct on the side of the shell.

[0011] FIG. 2 illustrates one example of a discharge valve for a linear compressor in accordance with a prior art. In one example, a conventional discharge valve 5a is made from PEEK material which is a kind of high-strength engineering plastics to be able to resist the high internal pressure from the compression space P (see FIG. 1), and has a shape with an increasing thickness towards the center. While one side of the discharge valve 5a is flat, the other side is convex towards the center to stay rigid and not bent even under excessive pressure. Naturally, the discharge valve 5a is placed such that its flat side is in contact with one end of a cylinder 2 (see FIG. 1) on the side of the compression space P (see FIG. 1), while its convex side is elastically supported by a discharge valve spring 5b (see FIG. 1).

[0012] FIG. 3 is a graph showing how the performance efficiency and the noise being produced are related to an increasing weight of a discharge valve for a linear compressor. According to the graph, as the weight of a discharge valve increases, impact force generated when the discharge valve collides with a cylinder increases, producing a louder noise at the same time, but the performance efficiency (compression efficiency) of a linear compressor is degraded. Although a discharge valve of smaller weight would reduce material costs and generate less noise, one should not reduce the weight of the discharge valve too much in order to secure a satisfactory level of strength for the discharge valve which is in contact with the high-pressure compression space. Therefore, it is desired to reduce the weight of a discharge valve within a range where a satisfactory level of strength for the discharge valve is ensured.

[0013] However, the discharge valve for a linear compressor according to a prior art, although it is made from high-strength yet expensive engineering plastics, is designed to be thicker towards the center to ensure its strength, so problems like an increase in weight and production cost, generation of louder noise during operation in proportion to the weight, degraded compression efficiency, etc., still remain unsolved. As most linear compressors today have a greater capacity, a larger discharge valve is needed accordingly, thereby making the aforementioned problems even worse.

DISCLOSURE OF INVENTION

Technical Problem

[0014] The present invention is conceived to solve the aforementioned problems in the prior art. An object of the present invention is to provide a discharge valve for a linear
compressor, which features a satisfactory level of strength with reduced weight by the use of dissimilar materials.

Technical Solution

[0015] According to an aspect of the present invention, there is provided a discharge valve for a linear compressor which is elastically supported in an axial direction by a discharge valve spring and which opens/closes a compression space defined between a cylinder and a piston, the discharge valve comprising: a body made from a metal material; and a coating layer made from a plastic material to wrap the body.

[0016] The discharge valve for a linear compressor of the present invention comprises: a center portion, on which the discharge valve spring is settled;

[0017] an expanded portion, which expands in a radial direction of the center portion with a uniform thickness and which has a plurality of reinforcement ribs; and a rim portion, which is formed in a circumference direction of the expanded portion with a uniform thickness.

[0018] In the discharge valve for a linear compressor of the present invention, the reinforcement ribs are uniformly arranged at the expanded portion along the circumference direction.

[0019] In the discharge valve for a linear compressor of the present invention, the reinforcement ribs have a decreasing height in an outward direction from the center portion to the rim portion.

[0020] In the discharge valve for a linear compressor of the present invention, the reinforcement ribs have a linear form.

[0021] In the discharge valve for a linear compressor of the present invention, the reinforcement ribs have a branched ‘Y-shaped’ form in an outward direction from the center portion to the rim portion.

[0022] In the discharge valve for a linear compressor of the present invention, the body is made from aluminum material, and the coating layer is made from PEEK material.

[0023] In another aspect, there is provided a discharge valve for a linear compressor which is elastically supported in an axial direction by a discharge valve spring and which opens/closes a compression space defined between a cylinder and a piston, the discharge valve comprising: a center portion on which a discharge valve spring is settled; an expanded portion, which expands in a radial direction of the center portion with a decreasing thickness and which has a plurality of weight reduction grooves; and a rim portion, which is formed in a circumference direction of the expanded portion with a uniform thickness.

[0024] In the discharge valve for a linear compressor of the present invention, the weight reduction grooves are uniformly arranged at the expanded portion.

[0025] In the discharge valve for a linear compressor of the present invention, the weight reduction grooves form a molecular pattern where at least two weight reduction grooves are arranged within a given section in a circumference direction of the expanded portion.

[0026] In the discharge valve for a linear compressor of the present invention, the weight reduction grooves are arranged in a radiation pattern about the center portion.

[0027] In the discharge valve for a linear compressor of the present invention, the weight reduction grooves are arranged at the expanded portion with a uniform depth.

[0028] In the discharge valve for a linear compressor of the present invention, the weight reduction grooves have a triangular shape.

[0029] In the discharge valve for a linear compressor of the present invention, the weight reduction grooves have a circular shape.

[0030] In the discharge valve for a linear compressor of the present invention, four neighboring weight reduction grooves are arranged in a diamond-shape.

ADVANTAGEOUS EFFECTS

[0031] The discharge valve for a linear compressor with the above-described configuration in accordance with the present invention may not have an optimum strength but its total weight is reduced by making the body from a relatively light metal material and wrapping the body with the coating layer made from a high-strength plastic material, such that a satisfactory level of strength is ensured despite the reduction in weight. As such, a linear compressor with the discharge valve of the present invention provides advantages of reduced production cost, higher compression efficiency while making less noise during the operation, reduced installation space for the discharge valve to achieve a broader space for discharge of refrigerant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] FIG. 1 illustrates one example of a linear compressor in accordance with a prior art;

[0033] FIG. 2 illustrates one example of a discharge valve for a linear compressor in accordance with a prior art;

[0034] FIG. 3 is a graph illustrating how performance efficiency and noise being generated by a conventional linear compressor change by weight of a discharge valve adapted to the linear compressor;

[0035] FIG. 4 illustrates one example of a linear compressor in accordance with the present invention;

[0036] FIG. 5 illustrates a first embodiment of a discharge valve for a linear compressor in accordance with the present invention;

[0037] FIG. 6 illustrates a cross-sectional view taken along line A-A of FIG. 5;

[0038] FIG. 7 illustrates a second embodiment of a discharge valve for a linear compressor in accordance with the present invention;

[0039] FIG. 8 illustrates a cross-sectional view taken along line B-B of FIG. 7;

[0040] FIG. 9 illustrates a third embodiment of a discharge valve for a linear compressor in accordance with the present invention; and

[0041] FIG. 10 illustrates a fourth embodiment of a discharge valve for a linear compressor in accordance with the present invention.

MODE FOR THE INVENTION

[0042] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0043] FIG. 4 illustrates one example of a linear compressor in accordance with the present invention. In this example, a linear compressor 100 of the present invention includes a cylinder 200, a piston 300, and a linear motor 400 constituted by an inner stator 420, an outer stator 440, and a permanent magnet 460, which are housed in a shell 110 or a hermetic container, and when the permanent magnet 460 linearly reciprocates by an interactive electromagnetic force between
the inner stator 420 and the outer stator 440, the piston 300 connected to the permanent magnet 460 also makes a linear reciprocating movement.

[0044] The inner stator 420 is affixed to an outer periphery of the cylinder 200, and the outer stator 440 is secured axially by a frame 520 and a motor cover 540. The frame 520 and the motor cover 540 are joined together by fastening members such as bolts, and the outer stator 440 is secured between the frame 520 and the motor cover 540. The frame 520 may be integrally formed with the cylinder 200, or the frame 520 may be manufactured separately and then coupled to the cylinder 200 later. The embodiment in FIG. 4 shows an example where the frame 520 and the cylinder 200 are integrated as one body.

[0045] A supporter 320 is connected to the rear side of the piston 300. Four front main springs 820 are supported on both ends by the supporter 320 and the motor cover 540. Also, four rear main springs 840 are supported on both ends by the supporter 320 and a back cover 560, and the back cover 560 is coupled to the rear side of the motor cover 540. A suction muffler 700 is provided on the rear side of the piston 300, through which refrigerant flows into the piston 300, so less noise is generated during suction feeding.

[0046] The interior of the piston 300 is hollowed to let the refrigerant fed through the suction muffler 700 be introduced and compressed in a compression space P defined between the cylinder 200 and the piston 300. A suction valve 810 is set at the front end of the piston 300. The suction valve 810 is opened during the suction when the refrigerant flows from the piston 300 into the compression space P, and it shuts the front end of the piston 300 to prevent backflow of the refrigerant from the compression space P to the piston 300.

[0047] When refrigerant inside the compression space P is compressed to a predetermined level or higher, it causes a discharge valve 620 which is seated at the front end of the cylinder 200 to open. The discharge valve 620 is elastically supported by a spiral discharge valve spring 630 inside a support cap 640 that is secured to one end of the cylinder 200. The high-pressure compressed refrigerant is then discharged into a discharge cap 660 via a hole which is formed in the support cap 640, and then escapes from the linear compressor 110 via a loop pipe L to be circulated, thereby making the refrigeration cycle work.

[0048] All of the components of the linear compressor 100 described above are supported by front and rear support springs 120 and 140 in assembled state, and stay at a certain distance away from the bottom of the shell 110. Since they are not in direct contact with the bottom of the shell 110, the shell 110 is free from the influence of vibrations that are produced by each component of the compressor 100 when compressing refrigerant. As a result, less vibration is delivered to the outside of the shell 110 and therefore, less noise is created due to the vibration of the shell 110.

[0049] FIG. 5 shows a first embodiment of a discharge valve for a linear compressor in accordance with the present invention, and FIG. 6 is a cross-sectional view taken along line A-A of FIG. 5. A discharge valve 620 in accordance with the first embodiment of the present invention includes a body 620A made from a relatively light metal material such as aluminum, and a coating layer 620B made from a high-strength plastic material such as PEEK to wrap the body. Needless to say, the discharge valve 620 made from the high-strength PEEK material only would not experience deformation caused by pressure difference, but production cost will increase. On the other hand, the discharge valve 620 made from an aluminum material only would suffer severe deformation because of pressure difference which outweighs the production cost advantage. Therefore, it is recommended to manufacture discharge valves using a variety of dissimilar materials that can reduce the weight and guarantee a satisfactory level of strength at the same time.

[0050] By the use of dissimilar materials, the discharge valve 620 may take the form of a relatively thin disk as shown in FIG. 5, which includes a spherical protruding holder 621 at the center to receive a discharge valve spring 630 (see FIG. 4) thereon, an expanded portion 622 that is expanded radially from the holder 621 at uniform thickness and that has parallel linear reinforcement ribs 622A arranged in a circumference direction with a fixed spacing from each other, and a rim 623 that is formed in the circumference direction at uniform thickness to sustain the pressure difference between inside and outside the compression space P. At this time, the holder 621 is thickest as it has a protruded portion to hold the discharge valve spring 630 (see FIG. 4), and the rim 623 has a relatively sufficient thickness to be able to sustain the pressure difference between inside and outside the compression space P. Meanwhile, the expanded portion 622 can be thin compared to the holder 621 and the rim 623 because it is already provided with the reinforcement ribs 622A. The reinforcement ribs 622A are formed to have their height decreased towards the rim 623 from the holder 621.

[0051] While one side of the discharge valve 620 has a stepped surface because of the presence of the holder 621 for the discharge valve spring 630 (see FIG. 4), the expanded portion 622 having the reinforcement ribs 622A, and the rim 623, the other side of the discharge valve 620 in contact with one end of the cylinder 200 (see FIG. 4) on the side of the compression space 2 has a flat surface with a groove in which a bolt head for fastening the suction valve 310 (see FIG. 4) slides.

[0052] FIG. 7 illustrates a second embodiment of a discharge valve for a linear compressor in accordance with the present invention, and FIG. 8 illustrates a cross-sectional view taken along line B-B of FIG. 7. Similar to the discharge valve 620 of the first embodiment, a discharge valve 1620 of the second embodiment includes a body 1620A made from a relatively light metal material, and a coating layer 1620B made from a high-strength plastic material to wrap the body, and the body 1620A is provided with a holder 1621, an expanded portion 1622, and a rim 1623. Because of the structural similarity between two embodiments, a detailed description on the structure will not be repeated. However, it should be noted that the expanded portion 1622 in the second embodiment includes ‘Y’ shape reinforcement ribs 1622 which are arranged in the circumference direction with a fixed spacing from each other, being branched out towards the rim 1623 from the holder 1621. As such, even if the reinforcement ribs 1622A may have a gradually decreasing height towards the rim 1623 from the holder 1621, a satisfactory level of strength can still be ensured.

[0053] FIG. 9 illustrates a third embodiment of a discharge valve for a linear compressor in accordance with the present invention. A discharge valve 2620 in accordance with the third embodiment of the present invention includes a spherical protruding holder 2621 at the center to receive a discharge valve spring 630 (see FIG. 4) thereon, an expanded portion 2622 that is expanded radially from the holder 2621 with decreasing thickness and that has a plurality of uniformly-
arrange weight reduction grooves 2622a, 2622b, 2622c, 2622d, and 2622e, and a rim 2623 that is formed in the circumference direction of the extended portion 2622 at uniform thickness to sustain the pressure difference between inside and outside the compression space P (see FIG. 4). The weight reduction grooves 2622a, 2622b, 2622c, 2622d, and 2622e form a molecular pattern M by means of partition walls which are arranged in sort of a molecular configuration, and such molecular patterns M are uniformly arranged in the circumferential direction. Needless to say, one side of the discharge valve 2620 in contact with the compression space is flat, but the other side of the discharge valve 2620 mounted with the discharge spring 630 (see FIG. 4) is formed to have increasing thickness towards the center. Nevertheless, the reduction of weight is still achieved because of the presence of weight reduction grooves 2622a, 2622b, 2622c, 2622d, and 2622e.

[0054] In detail, the molecular pattern M is divided by partition walls to have four triangular shaped weight reduction grooves 2622a, 2622b, 2622c, and 2622d, and one rectangular shaped weight reduction groove 2622e, and all of the weight reduction grooves 2622a, 2622b, 2622c, 2622d, and 2622e formed in the extended portion 2622 preferably have a uniform depth despite a varying thickness of the extended portion 2622 according to the position. Moreover, in order to ensure a satisfactory level of strength contrary to the formation of the weight reduction grooves 2622a, 2622b, 2622c, 2622d, and 2622e, it is preferable to form corners, i.e., crossing sites of partition walls, in a cylindrical shape and thicker compared to other portions of the partition walls.

[0055] The discharge valve 2620 with the aforementioned configuration can be formed by injection molding using high-strength plastic materials such as PEKK.

[0056] FIG. 10 illustrates a fourth embodiment of a discharge valve for a linear compressor in accordance with the present invention. Similar to the discharge valve 2620 in the third embodiment, a discharge valve 3620 of the fourth embodiment includes a holder 3621, an expanded portion 3622, and a rim 3623, where the expanded portion 3622 has weight reduction grooves 3622a, 3622b, 3622c, and 3622d with uniform depth and circular shape that are arranged in a radiation pattern about the holder 3621.

[0057] Here, the weight reduction grooves 3622a, 3622b, 3622c, and 3622d take the form of a pyramidal shape, and the number of the grooves formed increases towards the rim 3623 from the holder 3621. As indicated by dotted lines in FIG. 10, four neighboring weight reduction grooves 3622a, 3622b, 3622c, and 3622d form sort of a diamond-shaped molecular pattern M.

[0058] Moreover, similar to the discharge valve 2620 of the third embodiment, the discharge valve 3620 of the fourth embodiment can be formed by injection molding using high-strength plastic materials such as PEKK. Yet, the discharge valve 3620 has a simple structure compared as that of the third embodiment, and therefore it is easily injection-molded, and it also features a simple mold shape and a prolonged life.

[0059] The present invention has been described in detail with reference to the embodiments and the attached drawings. However, the scope of the present invention is not limited to the embodiments and the drawings, but defined by the appended claims.

1. A discharge valve for a linear compressor which is elastically supported in an axial direction by a discharge valve spring and which opens/closes a compression space defined between a cylinder and a piston, the discharge valve comprising:
   - a body made from a metal material; and
   - a coating layer made from a plastic material to wrap the body.
2. The discharge valve of claim 1, comprising:
   - a center portion, on which the discharge valve spring is settled;
   - an expanded portion, which expands in a radial direction of the center portion with a uniform thickness and which has a plurality of reinforcement ribs; and
   - a rim portion, which is formed in a circumference direction of the expanded portion with a uniform thickness.
3. The discharge valve of claim 2, wherein the reinforcement ribs are uniformly arranged at the expanded portion along the circumference direction.
4. The discharge valve of claim 2 or claim 3, wherein the reinforcement ribs have a decreasing height in an outward direction from the center portion to the rim portion.
5. The discharge valve of one of claims 2 through 4, wherein the reinforcement ribs have a linear form.
6. The discharge valve of one of claims 2 through 5, wherein the reinforcement ribs have a branched "Y-shaped" form in an outward direction from the center portion to the rim portion.
7. The discharge valve of one of claims 1 through 6, wherein the body is made from aluminum material, and the coating layer is made from PEKK material.
8. The discharge valve of claim 1, comprising:
   - a center portion on which a discharge valve spring is settled;
   - an expanded portion, which expands in a radial direction of the center portion with a decreasing thickness and which has a plurality of weight reduction grooves; and
   - a rim portion, which is formed in a circumference direction of the expanded portion with a uniform thickness.
9. The discharge valve of claim 8, wherein the weight reduction grooves are uniformly arranged at the expanded portion.
10. The discharge valve of claim 8 or claim 9, wherein the weight reduction grooves form a molecular pattern where at least two weight reduction grooves are arranged within a given section in a circumference direction of the expanded portion.
11. The discharge valve of one of claims 8 through 10, wherein the weight reduction grooves are arranged at the expanded portion in a radiation pattern about the center portion.
12. The discharge valve of one of claims 8 through 11, wherein the weight reduction grooves are arranged at the expanded portion with a uniform depth.
13. The discharge valve of one of claims 8 through 12, wherein the weight reduction grooves have a triangular shape.
14. The discharge valve of one of claims 8 through 12, wherein the weight reduction grooves have a circular shape.
15. The discharge valve of claim 14, wherein four neighboring weight reduction grooves are arranged in a diamond-shape.

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