Title: VALVE APPARATUS OF RECIPROCATING COMPRESSOR

Abstract: Provided is a valve apparatus for use in a reciprocating compressor, which includes a housing, a cylinder block having a plurality of cylinder bores, pistons reciprocally accommodated in the cylinder bores, a piston driving means for driving the pistons, a valve apparatus having suction valves and discharge valves installed opposite to bottom surfaces of the pistons, and suction chambers and discharge chambers formed at the housing and separated by the valve apparatus, characterized in that the valve apparatus includes a valve plate having a plurality of suction ports and discharge ports formed opposite to the bottom surfaces of the pistons and along its circumferential direction; dome-shaped shell valves detachably installed at the discharge ports adjacent to the discharge chamber; and a retainer disposed opposite to the valve plate with the dome-shaped shell valve interposed therebetween. Therefore, since the dome-shaped shell valve moves between the valve plate and the retainer to open/close the discharge port of the valve plate, it is possible to minimize a dead volume due to a space in the discharge port and maximize the efficiency of the compressor.
Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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Description

VALVE APPARATUS OF RECIPROCATING COMPRESSOR

Technical Field

The present invention relates to a valve apparatus of a reciprocating compressor, and more particularly, to a valve apparatus of a reciprocating compressor capable of minimizing a dead volume of a cylinder bore and integrally forming oil and coolant supply passages with a valve plate to simplify structure.

Background Art

A reciprocating compressor includes a piston, a piston driving apparatus, and a cylinder block having a cylinder bore through which the piston reciprocates. A suction/discharge valve apparatus is installed between a bottom surface of the cylinder bore and a lower surface of the piston to control inflow and outflow of a medium.

FIGS. IA to IC illustrate a variable displacement swash plate type compressor, as a typical example of a reciprocating compressor.

As shown in FIGS. IA to IC, a conventional variable displacement swash plate type compressor 10 includes a cylinder block 11 having a plurality of cylinder bores 11a arranged in parallel in a longitudinal direction at its inner periphery, a front housing 12 sealed in the front of the cylinder block 11, and a rear housing 13 sealed in the rear of the cylinder block 11 with a valve plate 13a interposed therebetween.

A swash plate chamber 14 is formed inside the front housing 12. One end of a drive shaft 15 passing through the swash plate chamber 14 is rotatably supported at the center of the front housing 12, and the other end of the drive shaft 15 is supported by a bearing 11c at a center shaft hole 11b in the cylinder block 11.

In addition, the drive shaft 15 includes a lug plate 16 press fitted thereinto in a spaced-apart manner, a varying-inclination swash plate 17 through which the drive shaft 15 passes, and a spring 27 installed between the lug plate 16 and the swash plate 17, resiliently supporting the swash plate 17 against the lug plate 16.

A pair of power transmission projections 16a each having a hinge hole 16b formed straight therethrough integrally project from one end of one surface of the lug plate 16 to be rotated together with the drive shaft 15. The swash plate 17 is inserted into the drive shaft 15 at a predetermined angle, and a hinge pin 18 fixed to the swash plate 17 is inserted into a hinge hole 16b formed at the power transmission projection 16a of the lug plate 16 such that the swash plate 17 rotates together with the lug plate 16, causing it to vary in inclination.

In addition, an outer periphery of the swash plate 17 is slidably installed via shoes...
20 into pistons 19 which are installed in the cylinder bores 11a.

Since the swash plate 17 is rotated in a tilted state, the pistons 19 into which the outer periphery is inserted via the shoes 20 reciprocate in the cylinder bores 11a of the cylinder block 11.

In addition, the rear housing 13 has a suction chamber 21 and a discharge chamber 22, and the valve plate 13a interposed between the rear housing 13 and the cylinder block 11 has suction ports 23 and discharge ports 24 corresponding to the cylinder bores 11a.

The suction ports 23 and the discharge ports 24 formed at the valve plate 13a have suction valves 25 and discharge valves 26 which open and close the suction ports 23 and the discharge ports 24 in response to pressure variation caused by reciprocation of the pistons 19.

In addition, the rear housing 13 includes a control valve (not shown) for communicating the swash plate chamber 14 and the suction chamber 21 such that a difference between a coolant suction pressure in the cylinder bore 11a and a pressure in the swash plate chamber 14 is varied to adjust the inclination of the swash plate 17.

The conventional variable displacement swash plate type compressor 10 adjusts the inclination of the swash plate 17 in response to a difference between a pressure in the swash plate chamber 14 and a suction pressure in the cylinder bores 11a. The inclination of the swash plate 17, in turn, determines the length of the strokes of the pistons 19 connected to the swash plate 17, which determines the discharge capacity of the compressor.

Meanwhile, as shown in FIGS. 1B and 1C, the suction valve 25 constituting the conventional valve apparatus is formed of a large plate that is adequate to cover the suction valves 25 and the cylinder bores 11a. Reference numeral 25b designates a lid of the suction valve.

In addition, a gasket 13g is disposed between the cylinder block 11 and the valve plate 13a, and the suction valve 25 is disposed between the gasket 13g and the valve plate 13a. That is, the gasket 13g overlaps the suction valve 25.

As described above, since the discharge port 24 formed at the valve plate 13a is opened/closed by the flat lid of the discharge valve 26, a space formed by the thickness of the valve plate 13a and the area of the discharge port 24 becomes a dead volume which severely reduces the efficiency of the compressor.

Disclosure of Invention

Technical Problem

It is an objective of the present invention to provide a valve apparatus for use in a
reciprocating compressor capable of minimizing a dead volume in a cylinder bore to
maximize efficiency.

[20] It is another objective of the present invention to provide a valve apparatus for use
in a reciprocating compressor capable of minimizing damage to a retainer.

[21] It is yet another objective of the present invention to provide a valve apparatus for
use in a reciprocating compressor capable of integrally installing an oil and coolant
circulation passage to simplify structure.

[22] Technical Solution

[23] One aspect of the present invention provides a valve apparatus for use in a re-
ciprocating compressor, which includes a housing, a cylinder block having a plurality
of cylinder bores, pistons that are reciprocally accommodated in the cylinder bores, re-
spectively, a piston driving means for driving the pistons, a valve apparatus having
suction valves and discharge valves installed opposite to the bottom surfaces of the
pistons, and suction chambers and discharge chambers formed at the housing and
separated by the valve apparatus, characterized in that the valve apparatus includes a
valve plate having a plurality of suction ports and discharge ports formed opposite to
the bottom surfaces of the pistons and in its circumferential direction; dome-shaped
shell valves detachably installed at the discharge ports adjacent to the discharge
chamber; and a retainer disposed opposite to the valve plate with the dome-shaped
shell valve interposed therebetween.

[24] Here, the discharge port, opposite to the dome-shaped shell valve, may include a
valve seat tapered in its axial direction.

[25] In addition, the dome-shaped shell valve may have a flat part formed around an
opening and bent outward.

[26] Further, the flat part of the dome-shaped shell valve may have a rim inclined toward
a convex part.

[27] Furthermore, the dome-shaped shell valve may be formed by connecting two
surfaces having different radiuses of curvature.

[28] In addition, an angle between a line connected from a bottom point of the dome-
shaped shell valve to a boundary point of the two curved surfaces and a tangential line
at the bottom point may be in a range of 0.5-3 times an angle between a line
connecting the boundary point of the two curved surfaces and a termination point of
the curved surfaces and the tangential line at the bottom point.

[29] Further, a distance between a center of a first radius of curvature and a center of a
second radius of curvature, including the bottom point, may be in a range of 0-20% of
the second radius of curvature.
Furthermore, an oil circulation groove may be formed at a surface of the valve plate opposite to the pistons.

In addition, a coolant circulation groove may be formed at a surface of the valve plate opposite to the pistons.

**Brief Description of the Drawings**

The above and other objects, features and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1A is a longitudinal cross-sectional view of an example of a conventional reciprocating compressor;

FIG. 1B is a detailed cross-sectional view of a coupling structure of a valve apparatus of FIG. 1A;

FIG. 1C is a front view of FIG. 1B;

FIG. 2 is a longitudinal cross-sectional view of a reciprocating compressor including a valve apparatus in accordance with an exemplary embodiment of the present invention;

FIG. 3 is a perspective view of a coupling structure of a valve apparatus and a cylinder block of FIG. 2;

FIG. 4 is an exploded perspective view of FIG. 3;

FIG. 5 is a perspective view of a coupling structure of a valve plate and a dome-shaped shell valve of FIG. 3;

FIG. 6A is a longitudinal cross-sectional view showing a closed state of a valve apparatus of FIG. 3;

FIG. 6B is a longitudinal cross-sectional view showing an opened state of a valve apparatus of FIG. 3;

FIG. 7 is a perspective view of a rear structure of a valve plate of FIG. 4;

FIG. 8 is a longitudinal cross-sectional view of a dome-shaped shell valve of FIG. 4; and

FIG. 9 is a longitudinal cross-sectional view of a reciprocating compressor including a valve apparatus in accordance with another exemplary embodiment of the present invention.

**Best Mode for Carrying Out the Invention**

Exemplary embodiments of the present invention will now be described in detail with reference to the accompanying drawings, wherein like reference numerals denote like elements throughout. The exemplary embodiments are described to make this disclosure sufficiently detailed to enable one of ordinary skill in the art to practice the
present invention.

An exemplary embodiment of the present invention will now be described with reference to FIGS. 2-8. Herein, a swash plate type compressor is taken as an example of a reciprocating compressor.

As shown, a swash plate type reciprocating compressor 1000 in accordance with an exemplary embodiment of the present invention includes a housing 100, a cylinder block 110 having a plurality of cylinder bores 110a, a drive shaft 140 rotatably supported by the cylinder block 110, a swash plate 150 connected to the drive shaft 140 and installed to vary in inclination as it rotates, pistons 200 accommodated in the cylinder bores 110a and capable of sliding back and forth with respect to the swash plate 150, a suction/discharge valve apparatus 300 installed opposite to a bottom surface of the piston 200, and a suction chamber 131 and a discharge chamber 132 formed at the housing 100 and separated by the suction/discharge valve apparatus 300.

The housing 100 includes a front housing 120 and a rear housing 130, the cylinder block 110 interposed therebetween.

In addition, the cylinder block 110 has eight cylinder bores 110a. Coolant introduced from the suction chamber 131 by the pistons 200 reciprocating in the cylinder bores 110a is continuously compressed.

The drive shaft 140 is rotatably supported by the front housing 120 and the cylinder block 110 via a bearing 400.

Further, the swash plate 150 is slidably coupled with the pistons 200 via shoes 201.

Furthermore, the swash plate 150 has connection projections 155 formed at its front and rear parts. Connection links 600 are interposed between the connection projections 155 and the drive shaft 140, which are connected to each other by hinge pins 610. Therefore, the connection links 600 and the connection projections 155, and the connection links 600 and the drive shaft 140, can be hinged to each other.

Meanwhile, the rear housing 130 has a suction chamber 131 and a discharge chamber 132.

The valve apparatus 300 includes suction valves 340 and discharge valves 350, with the valve plate 330 interposed therebetween. In addition, a retainer 360 is disposed at the discharge chamber 132 adjacent to the discharge valve 350.

Specifically, the valve plate 330 has suction ports 331 communicating the cylinder bores 110a and the suction chamber 131, and discharge ports 332 communicating the cylinder bores 110a and the discharge chamber 132.

In addition, the discharge valve 350, a dome-shaped shell valve, is detachably installed at the discharge port 332. At this time, in order to readily couple a bottom surface of the dome-shaped shell valve and the discharge port 332, the discharge port 332 opposite to the dome-shaped shell valve has a valve seat 332a tapered in its axial
direction. Therefore, the dome-shaped shell valve can be smoothly seated thereon when it is closed.

[58] In addition, the dome-shaped shell valve can be closed faster than a conventional flat valve, when closed by pressure of the discharged coolant.

[59] Furthermore, since a streamlined discharge passage is formed, when the dome-shaped shell valve is opened, the discharge speed from the cylinder bore can be faster and smoother than the case of the conventional flat discharge valve, thereby preventing pressure drop.

[60] In this case, when coolant is suctioned, it is very important to reduce a dead volume by positioning a bottom surface of the dome-shaped shell valve 350 adjacent to an inlet of the discharge port 332 and in maximal contact with an inner surface of the discharge port 332. That is, the dome-shaped shell valve 350 should almost fill the tapered discharge port 332.

[61] For this purpose, as shown in FIG. 8, the convex part 357 of the dome-shaped shell valve 350 may be formed of two curved surfaces R1 and R2 connected to each other. Especially, when an angle α1 between a line connected from a bottom point A1 of the dome-shaped shell valve 350 to a boundary point A2 of the two curved surfaces and a tangential line at the bottom point A1 is in a range of 0.5-3 times an angle α2 between a line connecting the boundary point A2 of the two curved surfaces and a termination point A3 of the curved surfaces and the tangential line at the bottom point A1, it is possible to minimize an inner space of the discharge port 332. In this case, a distance between a center O₁ of a first radius of curvature and a center O₂ of a second radius of curvature should be in a range of 0-20% of the second radius of curvature O₂.

[62] As described above, when the convex part of the dome-shaped shell valve 350 is formed of two curved surfaces, it is possible to reduce dead volume in the cylinder bores as well as minimize contact with an inner surface of the discharge port 332, thereby preventing leakage when coolant is suctioned.

[63] Eventually, the dome-shaped valve 350 moves to close the discharge port 332 when coolant is suctioned, and moves to open the discharge port 332 and is blocked by the retainer 360 when coolant is discharged (see FIGS. 6A and 6B). That is, the dome-shaped shell valve 350 reciprocates between the discharge port 332 and the retainer 360 to control the coolant flow.

[64] The retainer 360 may be formed of rubber material in order to obtain good sealing performance.

[65] In addition, the retainer 360 has sealing lines 361 and 362 protruding around its perimeter to perfectly separate the coolant discharged from the discharge port 132 from the coolant sucked from the suction chamber 131.

[66] Especially, the retainer 360 has a center pressure release hole 363 formed cor-
responding to the discharge port 332 of the valve plate 330, and a discharge communication hole 364 formed around the center pressure release hole 363.

Of course, the retainer 360 has a suction communication hole 365 formed corresponding to the suction port 331 of the valve plate 330.

The dome-shaped shell valve 350 has a flat part 358 bent outward around the opening. Therefore, it is possible to prevent damage to the retainer 360 on contact and minimize its movement due to discharge pressure of coolant.

Moreover, a periphery of the flat part 358 of the dome-shaped shell valve 350 is sloped toward the convex part to prevent damage to the retainer 360 due to fine burrs on frequent contact.

Meanwhile, an oil circulation groove 380 is formed at a surface of the valve plate 330 opposite to the pistons 200 to function as a passage for pumping oil gathered on a bottom through a control valve 800 using an oil pump 910.

In addition, a coolant circulation groove 390 is formed at a surface of the valve plate 330 opposite to the pistons 200 to function as a flow passage when coolant in the swash plate passes through the passage in the drive shaft 140.

The valve apparatus and the dome-shaped shell valve in accordance with the present invention will be adapted to another swash plate type compressor (the conventional compressor of FIG. 1) as shown in FIG. 9, as well as other general reciprocating compressors.

**Industrial Applicability**

As can be seen from the foregoing, since a dome-shaped shell valve moves between a valve plate and a retainer to open/close a discharge port of the valve plate, it is possible to minimize a dead volume due to a space in the discharge port.

In addition, when the dome-shaped shell valve is closed by pressure of discharged coolant, its response speed is faster than a conventional lid type valve.

Further, since a streamlined discharge passage is formed when the discharge port is open, a discharge speed from cylinder bores is faster and smoother than in the case of a conventional flat discharge valve, thus preventing pressure drop.

Furthermore, since the discharge port of the valve plate has a valve seat tapered in its axial direction, it is possible to readily engage the dome-shaped shell valve with the discharge port and obtain good sealing performance.

In addition, since the dome-shaped shell valve has a flat part bent outward around an opening thereof, it is possible to prevent damage to the retainer on contact and minimize movement thereof due to discharge pressure of coolant.

Further, a periphery of the flat part of the dome-shaped shell valve is sloped toward
the convex part to prevent damage to the retainer due to fine burrs.

Furthermore, since the dome-shaped shell valve is formed of two surfaces having different radiiues of curvature connected to each other, it is possible to minimize an inner space of the discharge port and obtain good sealing performance.

In addition, an oil circulation groove or a coolant circulation groove is formed at a surface of the valve plate opposite to the pistons, instead of forming a separate passage, thereby simplifying structure.

Although a few exemplary embodiments of the present invention have been shown and described, it will be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the spirit and scope of the invention defined by the appended claims and their equivalents.
Claims

[1] A valve apparatus for use in a reciprocating compressor, which comprises a housing, a cylinder block having a plurality of cylinder bores, pistons reciprocally accommodated in the cylinder bores, a piston driving means for driving the pistons, a valve apparatus having suction valves and discharge valves installed opposite to bottom surfaces of the pistons, and suction chambers and discharge chambers formed at the housing and separated by the valve apparatus, characterized in that the valve apparatus comprises:
a valve plate having a plurality of suction ports and discharge ports formed opposite to the bottom surfaces of the pistons and in its circumferential direction; dome-shaped shell valves detachably installed at the discharge ports adjacent to the discharge chamber; and
a retainer disposed opposite to the valve plate with the dome-shaped shell valve interposed therebetween.

[2] The valve apparatus for use in a reciprocating compressor according to claim 1, wherein the discharge port, opposite to the dome-shaped shell valve, has a valve seat tapered in its axial direction.

[3] The valve apparatus for use in a reciprocating compressor according to claim 2, wherein the dome-shaped shell valve has a flat part formed around an opening and bent outward.

[4] The valve apparatus for use in a reciprocating compressor according to claim 3, wherein the flat part of the dome-shaped shell valve has a rim inclined toward a convex part.

[5] The valve apparatus for use in a reciprocating compressor according to claim 2, wherein the dome-shaped shell valve is formed by connecting two surfaces having different radiiues of curvature.

[6] The valve apparatus for use in a reciprocating compressor according to claim 5, wherein an angle between a line connected from a bottom point of the dome-shaped shell valve to a boundary point of the two curved surfaces and a tangential line at the bottom point is in a range of 0.5-3 times an angle between a line connecting the boundary point of the two curved surfaces and a termination point of the curved surfaces and the tangential line at the bottom point.

[7] The valve apparatus for use in a reciprocating compressor according to claim 6, wherein a distance between a center of a first radius of curvature and a center of a second radius of curvature, comprising the bottom point, is in a range of 0-20% of the second radius of curvature.

[8] The valve apparatus for use in a reciprocating compressor according to any one
of claims 1 to 7, wherein an oil circulation groove is formed at a surface of the valve plate opposite to the pistons.

[9] The valve apparatus for use in a reciprocating compressor according to any one of claims 1 to 7, wherein a coolant circulation groove is formed at a surface of the valve plate opposite to the pistons.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

*F04B 27/08(2006.01)i, F04B 39/10(2006.01)i*

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC F04B1/00 - F04B53/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

- Korean Utility models and applications for Utility models since 1975
- Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS (KIPO internal) & keywords "compressor", "valve", "dead volume"

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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- Special categories of cited documents
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier application or patent but published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search: 30 AUGUST 2007 (30 08 2007)

Date of mailing of the international search report: 30 AUGUST 2007 (30.08.2007)

Name and mailing address of the ISA/KR

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Facsimile No: 82-42-472-7140

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