

RECIPROCATING COMPRESSOR, CONNECTING ROD AND CRANKSHAFT

TECHNICAL FIELD

- 5 The present disclosure relates to reciprocating compressors and in particular to the location of an oil feeding path in the crankshaft and connecting rod of a reciprocating compressor.

BACKGROUND

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Reciprocating compressors typically comprise an oil feeding path which draws oil from the bottom of the interior of the hermetic container and feeds the oil to the main bearing and slide portions of the piston and cylinder of the compressor.

15 SUMMARY

According to a first aspect of the present disclosure a reciprocating compressor comprises: an electric component and a compression component, disposed within a container, the compression component comprising a crankshaft, a connecting rod, a
20 piston and a cylinder block, the crankshaft comprising an eccentric shaft coupled to the connecting rod, the connecting rod being configured to cause the piston to reciprocate in a cylinder of the cylinder block when the crankshaft rotates, the electric component being configured to cause the crankshaft to rotate, the crankshaft comprising an oil supply mechanism configured to raise oil from an oil reservoir at
25 the base of the container to an oil supply port located on a surface of the eccentric shaft, the connecting rod comprising an oil communication passage having an oil communication passage inlet configured to be in fluid communication with the oil supply port for part of a reciprocation cycle of the reciprocating compressor, wherein the oil communication passage inlet and the oil supply port are provided at a position
30 displaced from a central axis of the connecting rod in the direction of an axis of rotation of the crankshaft.

Because the oil communication passage inlet and the oil supply port are displaced above the central axis of the connecting rod, they are provided away from the contact region of the eccentric shaft and the connecting rod where the forces are highest. Thus the contact area can be maximized in the region where the forces are highest. This provides for improved reliability of the reciprocating compressor.

In an embodiment, the crankshaft comprises a flange section which connects the eccentric shaft to a main shaft and the oil communication passage inlet and the oil supply port are provided at a position displaced from the central axis of the connecting rod in a direction away from the flange section.

In an embodiment, the oil supply port is provided in a groove running in a circumferential direction on the surface of the eccentric shaft and wherein the groove is provided at a position displaced from a central axis of the connecting rod in the direction of the axis of rotation of the crankshaft.

The connecting rod may comprise an oil communication passage outlet at an opposite end to the oil communication passage inlet, and wherein the oil communication passage outlet is provided at a position displaced from the central axis of the connecting rod in a direction of an axis of rotation of the crankshaft.

The oil communication passage outlet may be displaced from the central axis of the connecting rod in an opposite direction to the oil communication passage inlet and the oil supply port.

The oil communication passage may be provided at an angle to the central axis of the connecting rod. This angle may be an angle of more than 5 degrees to the central axis of the connecting rod. This angle may be an angle of less than 30 degrees.

A clearance of at least 10 percent of the height of the larger shaft hole may be provided between the oil communication passage inlet and a top surface the connecting rod. A clearance of at least 10 percent of the length of the eccentric shaft

may be provided between the oil supply port and an end surface of the eccentric shaft.

5 According to a second aspect of the present disclosure, a connecting rod for a reciprocating compressor is provided. The connecting rod has an eccentric shaft end comprising a larger shaft hole configured to receive an eccentric shaft and a piston end comprising a smaller shaft hole configured to receive a piston pin, the connecting rod comprising an oil communication passage running from an oil communication passage inlet on interior surface of the larger shaft hole to an oil
10 communication passage outlet provided on an interior surface of the smaller shaft hole, wherein the oil communication passage inlet is provided at a position displaced from a central axis of the connecting rod.

The oil communication passage outlet may be provided at a position displaced from
15 the central axis of the connecting rod. The oil communication passage outlet may be displaced from the central axis of the connecting rod in an opposite direction to the oil communication passage inlet.

The oil communication passage may be provided at an angle to the central axis of
20 the connecting rod. This angle may be an angle of more than 5 degrees to the central axis of the connecting rod. This angle may be an angle of less than 30 degrees.

A clearance of at least 10 percent of the height of the larger shaft hole may be
25 provided between the oil communication passage inlet and a top surface of the eccentric shaft end of the connecting rod.

According to a third aspect of the present disclosure a crankshaft for a reciprocating
compressor is provided. The crankshaft comprises a main shaft, an eccentric shaft
30 and a flange portion coupled to the main shaft and the eccentric shaft, the crankshaft comprising an oil supply mechanism configured to raise oil from the end of the main shaft distal to the flange portion to an oil supply port located on a peripheral surface of the eccentric shaft, wherein the oil supply port is located closer to an end of the eccentric shaft distal to the flange portion than to the flange portion.

In an embodiment, the oil supply port is provided in a groove running in a circumferential direction on the surface of the eccentric shaft and wherein the groove is located closer to an end of the eccentric shaft distal to the flange portion than to the flange portion.

In an embodiment, wherein a clearance of at least 10 percent of the length of the eccentric shaft is provided between the oil supply port and the end surface of the eccentric shaft at the end of the eccentric shaft distal to the flange portion.

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BRIEF DESCRIPTION OF THE DRAWINGS

In the following, embodiments of the present invention will be described as non-limiting examples with reference to the accompanying drawings in which:

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FIG.1 shows a cross sectional view of a reciprocating compressor according to an embodiment of the present invention;

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FIG.2A shows a crankshaft coupled to a connecting rod of a reciprocating compressor according to an embodiment of the present invention;

FIG.2B shows a crankshaft and a connecting rod of a reciprocating compressor according to an embodiment of the present invention;

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FIG.3A shows the force from compression action on a crankshaft and connecting rod of a reciprocating compressor according to an embodiment of the present invention;

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FIG.3B shows the distribution of the force from compression action on the eccentric shaft of a crankshaft in a reciprocating compressor according an embodiment of the present invention; and

FIG.3C shows the distribution of the force from compression action on the eccentric shaft of a crankshaft in a comparative example reciprocating compressor.

DETAILED DESCRIPTION

FIG.1 shows a cross sectional view of a reciprocating compressor according to an embodiment of the present invention. The reciprocating compressor is enclosed within a container 1. The container 1 is manufactured by, for example, a drawing process of an iron plate. Oil 2 is stored in the bottom portion of the container 1. The container 1 is filled with a working fluid 3. Hereinafter, a case where refrigerant is used as the working fluid 3 will be exemplarily described. However, the working fluid 3 is not particularly limited so long as it is a gas. As the refrigerant, for example, hydrocarbon-based refrigerant such as R600a, which is low in global warming coefficient, is used. A suction pipe 50 used to suction the working fluid 3 and a discharge pipe 57 used to discharge the working fluid 3 are connected to the container 1.

One end of the suction pipe 50 is communicated with an interior of the container 1, while the other end thereof is connected to a lower-pressure side (not shown) of the refrigeration cycle. One end of the discharge pipe 57 penetrates the container 1 and is communicated with a discharge muffler (not shown), while the other end thereof is connected to a higher-pressure side (not shown) of the refrigeration cycle.

A compression body 4 includes a compression component 9 and an electric component 6 for actuating the compression component 9. The compression body 4 is accommodated into the container 1 and is elastically supported on the container 1 by suspension springs 5. As a suspension, a known desired configuration may be used.

The electric component 6 comprises a stator 7 and a rotor 8. The stator 7 is fastened to a lower side of a cylinder block 15 by a bolt (not shown). The rotor 8 is placed at an inner side of the stator 7 and fastened to a main shaft 11 by shrink fitting (shrinkage-fit).

The compression component 9 comprises a crankshaft 12, the cylinder block 15, a piston 16, a connecting rod 22, a piston pin 23, etc.

The crankshaft 12 comprises a main shaft 11 and an eccentric shaft 10. The eccentric shaft 10 is connected to an upper end portion of the main shaft 11 such that an axis of the main shaft 11 and an axis of the eccentric shaft 10 are eccentric with respect to each other. The lower end portion of the main shaft 11 is immersed in a storage section of the oil 2. The electric component 6 causes the lower end portion of the main shaft 11 to rotate around its axis. A pump (not shown) is connected to a lower portion of the main shaft 11. The pump is immersed in the oil 2. The crankshaft 12 is provided with an oil feeding mechanism 51.

The oil feeding passage 10a is formed by drilling in a direction from an upper end of the eccentric shaft 10 using a machine such as an end mill or a drill press. An opening of the upper end is sealed (closed) by a sealing member 25. The sealing member 25 is fastened to the upper end by a fastening means such as screw engagement or welding. The oil feeding mechanism 51 is provided from the lower end portion of the main shaft 11 to an oil supplying port on an outer peripheral surface of the eccentric shaft 10 which is received in a larger shaft hole of the connecting rod 22. The oil 2 stored in the container 1 is fed to the oil supplying port on the outer peripheral surface of the eccentric shaft 10. The oil feeding mechanism 51 includes a spiral passage formed inside of the main shaft 11, a spiral groove formed on the outer peripheral surface of the main shaft 11, a pump attached to a lower portion of the main shaft 11, an oil feeding passage 10a within the eccentric shaft 10 and the oil supplying port. The components of the oil feeding mechanism 51 are in fluid communication with one another. The oil 2 flows from the pump attached to the lower portion of the main shaft 11, through the spiral passage, the spiral groove, and the oil feeding passage 10a, to the oil supplying port.

As described above, the crankshaft 12 is configured such that the oil feeding mechanism 51, the oil feeding passage 10a, and the oil supplying port are connected to each other, thereby forming an oil feeding path of the shaft 12. The oil feeding path of the crankshaft 12 is connected to an oil feeding path of the connecting rod 22 (as will be described later) including an oil communication passage 22a.

The cylinder block 15 includes the cylinder 14 and a bearing unit 24. Each of the cylinder 14 and the bearing unit 24 has a substantially cylindrical shape. The cylinder

14 and the bearing unit 24 are placed such that their axes cross each other at a substantially right angle.

The bearing unit 24 includes a main bearing 60. The main bearing 60 supports the
5 main shaft 11 of the crankshaft 12 such that the main shaft 11 is rotatable.

A valve plate 17, a suction valve 20, and a cylinder head 52 are fastened to an end surface of a head portion side of the cylinder 14 by a head bolt 53. The valve plate 17 includes a suction hole 18 and a discharge hole 19. Via the suction hole 18 and
10 the discharge hole 19, inside and outside of the compression chamber 13 are communicated with each other. A suction valve is provided on a surface of the valve plate 17 at the cylinder head 52 side, while a discharge valve 21 is provided on a surface of the valve plate 17 at an opposite side. The suction valve 20 opens and closes the suction hole 18, while the discharge valve 21 opens and closes the
15 discharge hole 19. The cylinder head 52 covers the valve plate 17. A suction muffler 54 is retained and secured between the valve plate 17 and the cylinder head 52. The valve plate 17 and the cylinder head 52 define a head space 56.

FIG.2A shows a crankshaft coupled to a connecting rod of a reciprocating
20 compressor according to an embodiment of the present invention and FIG.2B shows the crankshaft and the connecting rod separately.

As shown in FIG.2A and FIG.2B, the crankshaft 12 has a flange section 26 which joins the main shaft 11 to the eccentric shaft 10. The oil feeding passage 10a runs
25 from the interior of the main shaft 11 to an oil supplying port 28 located in a groove 27 in a peripheral surface of the eccentric shaft 10. The location of the groove 27 and the oil supplying port 28 is described in more detail below.

The connecting rod 22 has a larger shaft hole 32 which receives the eccentric shaft
30 10 and a smaller shaft hole 31 which receives the piston pin. The oil communication passage 22a runs from an oil communication passage inlet 29 provided on an interior surface of the larger shaft hole 32 to an oil communication passage outlet 30 provided on an interior surface of the smaller shaft hole 31.

As the crankshaft 12 rotates, the position of the eccentric shaft 10 relative to the cylinder block 15 changes. In the position shown in FIG.2A and FIG.2B, the eccentric shaft 10 is in its closest position to the cylinder block 15. In this position, the piston, which is coupled to the connecting rod 22 by a piston pin in the smaller shaft hole 31, is in its furthest depth into the cylinder and thus the compression space within the cylinder is at its smallest.

The groove 27 and the oil supplying port 28 are located on the peripheral surface of the eccentric shaft 10 in rotational position as shown in FIG.2A. That is, when the eccentric shaft is closest to the cylinder block 15, the oil supplying port 28 faces the oil communication passage inlet 29. The groove 27 runs part way around the circumference of the eccentric shaft 10 and therefore allows oil to flow from the oil feeding passage 10a to the oil communication passage 22a for a range of rotational positions of the eccentric shaft 10 around the position shown in FIG.2A and FIG.2B in which the eccentric shaft 10 is closest to the cylinder block 15.

The vertical position of the oil communication passage inlet 29 on the interior surface of the larger shaft hole 32 is offset above the central horizontal axis of the connecting rod 22. In other words, the oil communication passage inlet 29 on the interior surface of the larger shaft hole 32 is displaced from the central axis of the connecting rod in the direction of the rotational axis of the main shaft 11 of the crankshaft. The oil supplying port 28 and the groove 27 are located in corresponding positions on the eccentric shaft 10. This results in the portion of the eccentric shaft 10 between the flange section 26 of the crankshaft 12 and the level of the central axis of the connecting rod 22 not having an outlet or groove on its surface. Correspondingly, the interior surface of the larger shaft hole 32 does not include any inlet located below the level the central axis of the connecting rod.

The vertical position of the oil communication passage outlet 30 is offset below the central horizontal axis of the connecting rod 22. In other words, the oil communication passage outlet 30 is displaced from the central axis of the connecting rod 22 in the direction of the rotational axis of the piston pin.

Thus the oil communication passage 22a follows a diagonal path when viewed from the side as shown in FIG.2A and FIG.2B. The oil communication passage 22a is above the central axis of the connecting rod 22 at the larger shaft hole 32 end of the connecting rod 22 and is below the central axis of the connecting rod 22 at the
5 smaller shaft hole 31 end of the connecting rod 22.

The angle of the oil communication passage 22a to the central axis of the connecting rod may be less than 30 degrees. In some embodiments, the angle of the oil communication passage 22a to the central axis of the connecting rod is more than 5
10 degrees.

A clearance between the oil supplying port 28 and the top of the eccentric shaft 10 is provided. This clearance may be at least 10 percent of the length of the eccentric shaft. Similarly, a clearance between the top surface of the connecting rod 22 at the
15 larger shaft hole 32 end may be provided. Again, this clearance may be 10 percent of the height of the connecting rod 22 at the larger shaft hole end 32 of the connecting rod 22.

The advantages of the locating of the oil supplying port 28, the groove 27, and the oil
20 communication passage inlet 29 as described above will now be described with reference to FIG.3A, FIG.3B and FIG.3C.

FIG.3A shows the force from compression action on a crankshaft and connecting rod of a reciprocating compressor according to an embodiment of the present invention.
25 As shown in FIG.3A, when the crankshaft 12 rotates, the eccentric shaft 10 exerts a force on the connecting rod 22 which urges the piston into the cylinder. In turn, the connecting rod 22 experiences a force 40 from the piston. This force is transmitted by the connecting rod 22 to the eccentric shaft 10. The force is not evenly distributed over the eccentric shaft 10. As discussed above, the groove 27 in the eccentric shaft
30 10 which includes the oil supplying port 28 is located in a position above the central axis of the connecting rod 22. Similarly, the oil communication passage inlet 29 is located in a position above the central axis of the connecting rod 22.

FIG.3B shows the distribution of the force from compression action on the eccentric shaft of a crankshaft in a reciprocating compressor according an embodiment of the present invention. As shown in FIG.3B, the force 41 from the compression action is concentrated over a portion of the eccentric shaft in a region close to the flange section 26. This force is distributed over an area 42 of the surface of the eccentric shaft below the groove 27.

FIG.3C shows the distribution of the force from compression action on the eccentric shaft of a crankshaft in a comparative example reciprocating compressor. In the comparative example reciprocating compressor, the groove 27' is located in a position overlapping with the central axis of the connecting rod 22' and correspondingly, the oil communication passage inlet 29' is located on the central axis of the connecting rod 22'.

As shown in FIG.3C, the force from the compression action 43 is concentrated below the groove 27'. The total force from the compression action in the embodiment shown in FIG.3B and in the example shown in FIG.3C will be the same. However, the contact area over which the force is distributed will be smaller in the configuration of FIG.3C. The reason for this is that there is no contact between the groove 27' and the corresponding oil communication passage inlet 29'. Therefore, the area 44 is smaller compared with the area 42 of contact in FIG.3B. This results in the forces 43 on the lower part of the eccentric shaft being larger.

In view of the above, the location of the groove 27 and the oil communication passage inlet 29 in a position above the central axis of the connecting rod 22 allows the force from the compression action to be distributed over a larger area of the surface of the eccentric shaft 10, and correspondingly, over a larger area of the interior of the larger shaft hole of the connecting rod 22.

As a result, the groove 27 and the oil communication passage inlet are provided in a location that is displaced from the high pressure point. A similar advantage applies to the location of the oil communication passage outlet 30. At the smaller shaft hole end of the connecting rod, the high pressure area will be at the top of the interior surface of the smaller shaft hole. Thus, the oil communication passage outlet 30 is displaced

from the high pressure area by providing the oil communication passage outlet 30 below the central axis of the connecting rod 22.

Whilst the foregoing description has described exemplary embodiments, it will be
5 understood by those skilled in the art that many variations of the embodiments can be made within the scope and spirit of the present invention.

CLAIMS

1. A reciprocating compressor comprising:
 - an electric component and a compression component, disposed within a container,
 - the compression component comprising a crankshaft, a connecting rod, a piston and a cylinder block, the crankshaft comprising an eccentric shaft coupled to the connecting rod, the connecting rod being configured to cause the piston to reciprocate in a cylinder of the cylinder block when the crankshaft rotates,
 - the electric component being configured to cause the crankshaft to rotate,
 - the crankshaft comprising an oil supply mechanism configured to raise oil from an oil reservoir at the base of the container to an oil supply port located on a surface of the eccentric shaft, the connecting rod comprising an oil communication passage having an oil communication passage inlet configured to be in fluid communication with the oil supply port for part of a reciprocation cycle of the reciprocating compressor,
 - wherein the oil communication passage inlet and the oil supply port are provided at a position displaced from a central axis of the connecting rod in the direction of an axis of rotation of the crankshaft.
2. A reciprocating compressor according to claim 1, wherein the crankshaft comprises a flange section which connects the eccentric shaft to a main shaft and the oil communication passage inlet and the oil supply port are provided at a position displaced from the central axis of the connecting rod in a direction away from the flange section.
3. A reciprocating compressor according to claim 1 or claim 2, wherein the oil supply port is provided in a groove running in a circumferential direction on the surface of the eccentric shaft and wherein the groove is provided at a position displaced from a central axis of the connecting rod in the direction of the axis of rotation of the crankshaft.

4. A reciprocating compressor according to any preceding claim, wherein the connecting rod comprises an oil communication passage outlet at an opposite end to the oil communication passage inlet, and wherein the oil communication passage outlet is provided at a position displaced from the central axis of the connecting rod in a direction of an axis of rotation of the crankshaft.
5. A reciprocating compressor according to claim 4, wherein the oil communication passage outlet is displaced from the central axis of the connecting rod in an opposite direction to the oil communication passage inlet and the oil supply port.
6. A reciprocating compressor according to any preceding claim, wherein the oil communication passage is at an angle of more than 5 degrees to the central axis of the connecting rod.
7. A reciprocating compressor according to any preceding claim, wherein the oil communication passage is at an angle of less than 30 degrees to the central axis of the connecting rod.
8. A reciprocating compressor according to any preceding claim, wherein a clearance of at least 10 percent of the height of the larger shaft hole is provided between the oil communication passage inlet and a top surface of the connecting rod.
9. A reciprocating compressor according to any preceding claim, wherein a clearance of at least 10 percent of the length of the eccentric shaft is provided between the oil supply port and an end surface of the eccentric shaft.
10. A connecting rod for a reciprocating compressor, the connecting rod having an eccentric shaft end comprising a larger shaft hole configured to receive an eccentric shaft and a piston end comprising a smaller shaft hole configured to receive a piston pin, the connecting rod comprising an oil

communication passage running from an oil communication passage inlet on interior surface of the larger shaft hole to an oil communication passage outlet provided on an interior surface of the smaller shaft hole, wherein the oil communication passage inlet is provided at a position displaced from a central axis of the connecting rod.

11. A connecting rod according to claim 10, wherein the oil communication passage outlet is provided at a position displaced from the central axis of the connecting rod.
12. A connecting rod according to claim 11, wherein the oil communication passage outlet is displaced from the central axis of the connecting rod in an opposite direction to the oil communication passage inlet.
13. A connecting rod according to any one of claims 10 to 12, wherein the oil communication passage is at an angle of more than 5 degrees to the central axis of the connecting rod.
14. A connecting rod according to any one of claims 10 to 13, wherein the oil communication passage is at an angle of less than 30 degrees to the central axis of the connecting rod.
15. A connecting rod according to any one of claims 10 to 14, wherein a clearance of at least 10 percent of the height of the larger shaft hole is provided between the oil communication passage inlet and a top surface of the eccentric shaft end of the connecting rod.
16. A crankshaft for a reciprocating compressor, the crankshaft comprising a main shaft, an eccentric shaft and a flange portion coupled to the main shaft and the eccentric shaft, the crankshaft comprising an oil supply mechanism configured to raise oil from the end of the main shaft distal to the flange portion to an oil supply port located on a peripheral surface of the eccentric shaft, wherein the oil supply port is located closer to an end of the eccentric shaft distal to the flange portion than to the flange portion.

17. A crankshaft according to claim 16, wherein the oil supply port is provided in a groove running in a circumferential direction on the surface of the eccentric shaft and wherein the groove is located closer to an end of the eccentric shaft distal to the flange portion than to the flange portion.
18. A crankshaft according to claim 16 or claim 17, wherein a clearance of at least 10 percent of the length of the eccentric shaft is provided between the oil supply port and the end surface of the eccentric shaft at the end of the eccentric shaft distal to the flange portion.