

CONNECTING ROD OF COMPRESSOR AND COMPRESSOR

Field of the Invention

[0001] The present invention relates generally to reciprocating compressor, and more particularly to a connecting rod with reduced contact areas.

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Background of the Invention

[0002] A reciprocating compressor includes a hermetic casing, a compressing unit to compress the refrigerant, and a drive unit to drive the compressing unit, where the compressing unit and the drive unit are installed in the hermetic casing. The compressing unit includes a cylinder block with a compression chamber, a cylinder head, and a piston
10 rectilinearly reciprocating in the compression chamber. The drive unit includes a stator, a rotator, and a rotating shaft. Further, an eccentric shaft is integrally provided on a predetermined portion of the rotating shaft, and eccentrically rotates. A connecting rod is provided between the eccentric shaft and the piston to convert an eccentric rotating motion of the eccentric shaft into a reciprocating motion, thus reciprocating the piston.

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[0003] The reciprocating compressor is configured such that the eccentric shaft is integrally rotated to the rotor of the drive unit, and has an eccentric portion at the upper part. The connecting rod has two ends; a larger diameter hole is formed at one end for connecting the eccentric portion of the eccentric shaft; and a smaller diameter hole is formed at the other end for coupling to the piston. As shown in **FIGs 1(A)-(E)**, a
20 conventional connecting rod **3** comprises a larger diameter hole **31** at one end, a smaller diameter hole **32** at the other end, and a connecting portion **33** connecting both holes. The holes are formed by cylindrical walls. **FIG 1(A)** shows an isometric view of the

connecting rod 3 from the bottom; **FIG 1(B)** shows a plan view of the connecting rod 3 from the top, where the A-A cross section line is shown; **FIG 1(C)** shows a side view of the connecting rod 3 from the distal part of the larger diameter hole; **FIG 1(D)** shows a cross-section view of the connecting rod 3 along the A-A line shown in **FIG 1(B)**; **FIG 1(E)** shows a plan view of the connecting rod 3 from the bottom. It is apparent that the cylindrical walls in each of the holes are uniform and symmetrical.

[0004] During the operation of the reciprocating compressor, the frictions exist in the contact surfaces between the eccentric shaft and the larger diameter hole and between the piston and the smaller diameter hole, resulting in the loss of efficiency. Hence, a paramount factor in enhancing the compressor efficiency is to reduce these frictional losses at the connecting rod.

[0005] Intensive studies have been conducted considering the problem of frictional loss at the connecting rod. One of the solutions to the above-mentioned problem is to introduce bushing to alleviate the friction created between the connecting rod and the rotating eccentric shaft. In Patent US 6,997,101, the bushing is press-fitted between the connecting rod and the crankshaft. In Patent US 7,024,960, it describes a bushing rotatably connected with the eccentric portion, and has a sloping side on its outer surface with a predetermined slope in regard to an axis of the eccentric portion. Thus, the frictional loss created between the connecting rod and the eccentric shaft may be reduced. However, to insert the sleeve into the connecting rod, there will be complexity in assembly and an additional component.

[0006] Another solution to the problem is to decrease the hole diameter on the connecting rod. However, the smaller contact area between the connecting rod and the eccentric shaft

with a constant compression force, experience greater compression pressure and may result in wear and breakage of the connecting rod.

[0007] Other solutions proposed may involve a change in material of the connecting rod, which may result in higher cost.

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Summary of the Invention

[0008] One aspect of the present invention provides a connecting rod for being used in a reciprocating compressor. In one embodiment, the connecting rod comprises a connecting portion having at least a connecting hole formed at a distal end of the connecting portion, wherein the connecting hole has an interior surface area that operationally experiencing
10 non-linear operating load across the interior surface area, the non-linear operating load includes a high operating load at a high load region of the interior surface area, the connecting holes are adapted with at least the high load region with a structural strength to withstand the high operating load. Accordingly, the interior surface area can be adapted with a non-uniform height across the surface area based on the non-linear operating load,
15 and the height over the high load region is higher than a region off the high load region.

[0009] In one embodiment of the connecting rod, the distal part of the connecting hole is tapered toward the distal point. In a further embodiment, the connecting portion has a second connecting hole at another distal end, wherein the second connecting hole has a smaller diameter than that of the connecting hole. An interior surface area of the second
20 connecting hole may have a non-uniform height across the surface area, and the height over a high operation load region of the second connecting hole is higher than a region off the high load operating region. The distal part of the connecting hole and/or the second smaller diameter hole may be tapered toward the distal point. In another embodiment,

when the top and bottom of the connecting hole are tapered, the gradient of tapering on the bottom is steeper than the one at the top, or the gradient of tapering on the top is steeper than the one at the bottom. It is also possible that, the gradient of tapering at the top is the same as the one at the bottom.

5 **[0010]** In a further embodiment, the connecting rod may further comprise a recession in the top interior surface over at the region off the high load region, resulting the height over the high load region is higher than the region at the connecting hole. In an alternatively embodiment, the connecting rod may comprise another recession in the bottom interior surface over at the region off the high load region. The interior recessions are symmetrical
10 in the top and the bottom. It is also possible that the interior recession in the bottom having a different size from the one in the top. Yet, it is also possible that the interior recession at the bottom is the same as the one on the top.

[0011] In yet a further embodiment, the connecting rod further comprises a step in the top interior surface over at the region off the high load region, resulting the height over the
15 height load region is higher than the region at the connecting hole. The connecting rod may further comprise another step in the bottom interior surface over at the region off the high load region. When the top and bottom interior surface of the connecting hole have the steps, the step at the bottom is smaller than the one of the top, or both bottom and the top steps are the same with each other.

20 **[0012]** Another aspect of the present invention provides a reciprocating compressor comprising a hermetic casing, a compression unit, and a driving unit; wherein the compression unit and the driving unit are installed in the hermetic casing; wherein the compression unit comprises a connecting rod for connecting an eccentric shaft of the

driving unit and a piston pin of a piston in the compression unit so as to convert a rotational force into a rectilinear force; and wherein the connecting rod comprises a connecting portion having at least a connecting hole formed at a distal end of the connecting portion, wherein the connecting hole has an interior surface area that
5 operationally experiencing non-linear operating load across the interior surface area, the non-linear operating load includes a high operating load at a high load region of the interior surface area, the connecting holes are adapted with at least the high load region with a structural strength to withstand the high operating load, wherein the interior surface area has a non-uniform height across the surface area adapted based on the non-linear operating
10 load, and the height over the high load region is higher than a region off the high load region.

[0013] In one embodiment, the interior surface area of the connecting hole has a non-uniform height interior surface across the circumferential, the distal end of the interior surface area has a height lower than that of the proximal end in relation to the connecting
15 portion. The distal part of the connecting hole may be tapered toward the distal point. when both the top and bottom of connecting hole are tapered, the gradient of tapering on the bottom is symmetrical with the one at the top. It is also possible that gradient of tapering is different between the top and the bottom.

[0014] In an alternative embodiment, the distal part of the connecting hole has a recession
20 in the interior surface thereon. In a further alternative embodiment, the distal part of the connecting hole may have recessions in the top and the bottom of the interior surface. When the top and bottom of the connecting hole have interior recessions, the interior

recession in the bottom is symmetrical with the one at the top. It is also possible to adapt a recession in the bottom with a different size from the one in the top.

[0015] In yet another embodiment, the distal part of the connecting hole has a step. In a further alternative embodiment, the distal part of the connecting hole may have steps in the top and the bottom of the interior surface. When the top and bottom of the connecting hole have steps, the step in the bottom is symmetrical with the one at the top. It is also possible to adapt a step in the bottom with a different size from the one on the top.

[0016] The objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0017] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0018] FIGs 1(A)-(E) show a conventional connecting rod in the prior art.

[0019] FIG 2 is an isometric view of the reciprocating compressor of one embodiment of the present invention.

[0020] FIGs 3(A)-(F) show the connecting rod in accordance with one embodiment of the present invention.

[0021] FIGs 4(A)-(E) show the connecting rod in accordance with one embodiment of the present invention.

[0022] FIGs 5(A)-(E) show the connecting rod in accordance with one embodiment of the present invention.

5 [0023] FIGs 6(A)-(F) show the connecting rod in accordance with one embodiment of the present invention.

[0024] FIGs 7(A)-(E) show the connecting rod in accordance with one embodiment of the present invention.

[0025] FIG. 8 illustrates the reaction force on the connecting rod, due to the crankshaft
10 under compression load, where the compression load is illustrated by the arrows.

[0026] FIG 9A illustrates a graph indicating the reaction force on the connecting rod of FIG 8 over its crank angle.

[0027] FIG 9B shows the connecting rod of FIG 8 experiences the maximum compression force due to the eccentric shaft, moments before it reaches its top dead center.

15 **Detailed Description of the Invention**

[0028] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0029] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this
20 application in order to more fully describe the state of art to which this invention pertains.

[0030] The inventors of the present invention discovered that the contact surfaces between the large diameter hole **801** and the eccentric shaft **802** and between the smaller diameter hole and the piston pin **807** of the piston **804** bear differential compression load. It is also to be noted that, some of the piston pin **807** and/or the eccentric shaft **802** are configured to be slightly tilted in relation to the contacting surfaces of the large and small diameter holes. Such tilted configuration is commonly adapted and it is provided herewith for illustrations only. It places no limitation on scope of the invention because the proposed embodiments of the present invention shall be equally applicable to a shaft that is oriented in any other angles, such as 90 degrees upright. As shown in **FIG 8**, the reaction force on the connecting rod **800**, due to the eccentric shaft **802** under compression load, is unevenly distributed, where the cylindrical wall of the larger diameter hole at the distal part **805** bears less compression load than the surface at the opposing end **806**. Accordingly, for the same or substantially the same connecting rod's configurations adapted for a specific reciprocating compressor, it is desired that the inner surface (or the cylindrical wall) over at the region remains the same as the intended configuration, whilst the remaining region of the inner surface is configured to be smaller than the region. In other words, the inventors of the present invention suggest that the inner contact surface of the connecting rod for contacting with the shaft can be adapted with a non-uniform width/height across the surface area. The reduced surface area only occurs at the area where the operating load is determined to be relatively low or at the lowest. Such configuration strategically reduces the surface area of the contact between the connecting rod and the shaft, without compromising the structural strength of the connecting rod.

[0031] **FIG 9(A)** is a graph illustrates the force acting on the larger diameter hole of the connecting rod against its' radial position as shown in **FIG 9(B)**. As shown in the graph,

the forces acting on the inner diameter surfaces of the connecting rod **800** are not constant through out. It shows that when the connecting rod is in a region near to the top dead centre, the acting force is at the highest, whereas the rest of the region, the force acting on the connecting rod **800** is at a relatively low level. Accordingly, the inventors suggest the
5 connecting rod to have a structure that is able to sustain the maximum force while reducing the contact surfaces strategically only at the areas where the acting forces are low.

[0032] Referring again to **FIG 9(A)**, the force acting on the connecting rod **800** is started to have a notable increase from the radial positions of about 270 degree to about 405 degree. In this example, the connecting rod is rotated clockwise on the compressor. It is
10 understood that the graph exemplifies the acting force imposes on a specific connecting rod only, and a connecting rod with another configuration for other implementation may experience acting force in different magnitudes and angles, although it is agreeable that the general behavior of the graph should follow the same or substantially the same trend. Further, specifically, these angular values can be varied under different operating
15 conditions of the compressor and the timing of the reed opening. The connecting rod **800** experiences the maximum compression force due to the eccentric shaft **802**, moments before it reaches its top dead center. As exemplified in **FIGs. 9(A)** and **9(B)**, when the radial position of the connecting ring of the connecting rod with the larger diameter is at around 270-405 degree, the acting force is at a peak region. It is well understood that the
20 range provided herewith may differ from case to case depending on the actual configuration of the compressors.

[0033] Therefore, it is the primary objective of the present invention to provide a connecting rod adapted with at least the part that is operationally experiencing maximum

or relatively higher operating load able to withstand the load. The remaining part, i.e. radial positions beyond 270-405 degrees that is operationally experiencing substantially lower load, may be adapted with a reduced contact area between the connecting rod and the eccentric shaft. For a reciprocating compressor, the reduction of the contact area

5 between the connecting rod and the eccentric shaft is strategically located at least at the distal part of the larger diameter hole so that the reduction in contact area between the connecting rod **800** and the eccentric shaft **802** is away from the high compression load region. As a result, while it reduces the frictional area and thus reduces the input power, there is no compromise or sacrifice to reliability. The reduction of contact area can be

10 similarly applied at the smaller mounting hole of the connecting rod. However, effects of the reduction in input power according to the invention will be less significant at the smaller mounting hole of the connecting rod than the larger diameter mounting hole. In addition, this invention involves a reduction in material, and thus aids in cost saving.

[0034] The present invention provides a reciprocating compressor with a connecting rod

15 that has reduced frictions between the connecting rod and an eccentric shaft and piston. **FIG 2** shows an isometric view of the reciprocating compressor of the present invention with the relevant parts being labeled, with the remaining parts being conventional; thus no further details for the remaining parts will be provided herein, so as not to obscure the present invention.

20 **[0035]** The reciprocating compressor **10** comprises a piston **1** for the function of compression, an eccentric shaft **2** for converting a rotational force into a rectilinear force, and a connecting rod **3** for connecting a piston pin of the piston **1** and the eccentric shaft **2** so as to enable the piston to make reciprocating movement in a compression chamber of

the reciprocating compressor. As detailed herein below, the connecting rod has the strategic reduction of contact areas in one or two of the holes at its ends, so that the reciprocating compressor **10** of the present invention has reduced frictional loss, and therefore increased efficiency.

5 **[0036]** The present invention also provides a connecting rod that has a strategic reduction of contact areas between the larger diameter hole and the eccentric shaft and between the smaller diameter hole and the piston. The reduction of the contact areas is located in the distal part of the holes in relation to the connecting portion. It is to be noted that during the reciprocating actions, the inner surface area of each connecting hole (large and small ones)
10 does not experience the same amount of load from the connecting shaft. In a reciprocating compressor, it was identified that the inner surfaces at the two distal ends of the connecting rod receive relatively smaller load than that of opposing surfaces. Therefore, it is possible to reduce the frictional surface at these areas without compromising the durability of the connecting rod as much as possible, by reducing the contact surface where the load of the
15 connecting surface is at a minimal level. On the other hand, the part of the connecting rod that is operationally experiencing relatively high compression load shall be adapted with an intended configuration that is structurally strong for at least able to withstand the high compression load operationally.

[0037] In one embodiment, the strategic reduction of the contact areas is made at the distal
20 part of the larger diameter hole. In another embodiment, the strategic reduction of the contact areas is made at the distal part of the smaller diameter hole. In another embodiment, the strategic reduction of the contact areas is made at the distal parts of both holes.

[0038] It is to be noted that the strategic reduction of the contact areas in the connecting rod can be made in various configurations. The following embodiments are provided for the sole purpose of illustrating the strategic reduction of contact areas in the connecting rod in accordance with the principles of the present invention. The connecting rod is assigned
5 with a new numerical number in each figure for the purpose of clarity.

[0039] Referring now to **FIGs 3(A)-(F)**, there is provided a connecting rod in accordance with one embodiment of the present invention. As shown in **FIGs 3(A)-(F)**, the connecting rod **31** has a configuration that the top and bottom of the cylinder wall of only the larger diameter hole **311** for receiving the eccentric shaft are tapered flat toward the
10 distal point. The gradient of tapering at the top and the bottom is substantially symmetrical. **FIG 3(A)** shows an isometric view of the connecting rod **31** from the bottom; **FIG 3(B)** shows a plan view of the connecting rod **31** from the top, where the A-A cross section line is shown; **FIG 3(C)** shows a cross-section view of the connecting rod **31** along the A-A line shown in **FIG 3(B)**; **FIG 3(D)** shows a side view of the connecting rod
15 **31** from the distal part of the smaller diameter hole; **FIG 3(E)** shows a side view of the connecting rod **31** from the distal part of the larger diameter hole; **FIG 3(F)** shows a plan view of the connecting rod **31** from the bottom. As configured, regions on the connecting rod **31** that experience lesser compression load are designed to have a smaller surface area of contact with the eccentric shaft. Operating force distribution at the corresponding
20 angular position on the connecting rod, such as one exemplifies in **FIG 9(A)**, shall be taken into account in deciding the inner surface area required on the connecting hole.

[0040] In an alternative embodiment, the connecting hole may be adapted with a non-symmetrical gradient of tapering at the top and the bottom. For example, gradient at the bottom may be steeper than on the top or vice versa.

[0041] Referring now to **FIGs 4(A)-(E)**, there is provided a connecting rod in accordance with another embodiment of the present invention. As shown in **FIGs 4(A)-(E)**, the connecting rod **51** has a configuration that the surface area of the cylinder wall of the larger diameter hole **411** in contact with eccentric shaft is non-uniform along the inner circumferential surface, where at the distal part of the larger diameter hole **411**, the interiors of the top and bottom are configured to have recessions, resulting in a smaller contact surface with the eccentric shaft. Both recessions on the top and the bottom sides are symmetrically sized. **FIG 4(A)** shows an isometric view of the connecting rod **41** from the bottom; **FIG 4(B)** shows a plan view of the connecting rod **41** from the top, where a A-A cross section line and a B-B cross section line are shown; **FIG 4(C)** shows a side cross section view of the larger diameter hole of the connecting rod **41** along the A-A line shown in **FIG. 4(B)**; **FIG 4(D)** shows a cross-section view of the connecting rod **41** along the B-B line shown in **FIG 4(B)**; **FIG 4(E)** shows a plan view of the connecting rod **41** from the bottom. As configured, regions on the connecting rod **41** that experience lesser compression load are designed to have a smaller surface area of contact with the eccentric shaft. The embodiment of the present invention illustrated in **FIGs 4(A)-(E)** is provided that the eccentric shaft rotates clockwise. Operating force distribution at the corresponding angular position on the connecting rod, such as one exemplifies in **FIG 9(A)**, shall be taken into account in deciding the inner surface area required on the connecting hole.

[0042] In one alternative embodiment, the connecting hole may be adapted with a non-symmetrical interior recession's configuration on the top and at the bottom. For example, the interior recession on the top is smaller than that at the bottom. In a further alternative embodiment, the interior recession on the top is larger than that at the bottom.

5 [0043] Referring now to **FIGs 5(A)-(E)**, there is provided a connecting rod in accordance with another embodiment of the present invention. As shown in **FIGs 5(A)-(E)**, the connecting rod **51** has a configuration that at the distal part of the larger diameter hole **511**, the top and bottom walls are configured to have steps, resulting in a smaller contact surface with the eccentric shaft. Both steps on the top and the bottom are symmetrically sized.

10 **FIG 5(A)** shows an isometric view of the connecting rod **51** from the bottom; **FIG 5(B)** shows a plan view of the connecting rod **51** from the top, where the A-A cross section line is shown; **FIG 5(C)** shows a side view of the connecting rod **51** from the distal part of the larger diameter hole; **FIG 5(D)** shows a cross-section view of the connecting rod **51** along the A-A line shown in **FIG 5(B)**; **FIG 5(E)** shows a plan view of the connecting rod **51**

15 from the bottom. As configured, regions on the connecting rod **51** that experience lesser compression load are designed to have a smaller surface area of contact with the eccentric shaft. Operating force distribution at the corresponding angular position on the connecting rod, such as one exemplifies in **FIG 9(A)**, shall be taken into account in deciding the inner surface area required on the connecting hole.

20 [0044] In an alternative embodiment, the connecting hole may be adapted with a non-symmetrical steps' configuration on the top and at the bottom. For example, the step on the top is smaller than that at the bottom. In another alternative embodiment, the step on the top is larger than that at the bottom.

[0045] As shown in **FIGs. 3-5**, the top and bottom views in particular, it is also shown that the region that are being configured with a reduced surface area that are substantially symmetrical over the circumferential with reference to the longitudinal axis of the connecting rod. As explained above through **FIGs. 9(A)** and **9(B)**, the inner surface area (at the larger diameter hole or the small diameter hole) operationally experiences relatively high load only at a specific range of angular positions then the rest of the positions. Based on this finding, it is therefore desired that the connecting rod be configured with an inner surface area that is non-uniform along the inner circumferential surface of the connecting hole, wherein at least the portion of the connecting rod (i.e. at the specific range of angular positions) be configured with an intended structure that is able to withstand the maximum operating load; whilst the remaining portion be configured with a structure having a relatively reduced contact surface area thereby reduced the frictional resistant between shaft and the connecting rod when it is rotated outside of the specific range of angular positions.

[0046] Referring now to **FIGs 6(A)-(F)**, there is provided a connecting rod in accordance with another embodiment of the present invention. As shown in **FIGs 6(A)-(F)**, the connecting rod **61** has a configuration that at the distal part of the smaller hole **612** for receiving the piston pin, the top and bottom walls are tapered toward the distal part. In one embodiment, the gradient of tapering at the top and the bottom of the smaller hole is substantially symmetrical. **FIG 6(A)** shows an isometric view of the connecting rod **61** from the bottom; **FIG 6(B)** shows a plan view of the connecting rod **61** from the top, where the A-A cross section line is shown; **FIG 6(C)** shows a cross-section view of the connecting rod **61** along the A-A line shown in **FIG 6(B)**; **FIG 6(D)** shows a side view of the connecting rod **61** from the distal part of the smaller diameter hole; **FIG 6(E)** shows a

side view of the connecting rod **61** from the distal part of the larger diameter hole; **FIG 6(F)** shows a plan view of the connecting rod **61** from the bottom. As configured, regions on the connecting rod **61** that experience lesser compression load are designed to have a smaller inner surface area of contact with the piston pin. Operating force distribution at the
5 corresponding angular position on the connecting rod, such as one exemplifies in **FIG 9(A)**, shall be taken into account in deciding the inner surface area required on the connecting hole.

[0047] In an alternative embodiment, the connecting hole may be adapted with a non-symmetrical gradient of tapering on the top and at the bottom. For example, the gradient
10 of tapering on the top can be made steeper than at the bottom, resulting in a smaller contact surface with the piston pin, or vice versa.

[0048] Referring now to **FIGs 7(A)-(E)**, there is provided a connecting rod in accordance with yet another embodiment of the present invention. As shown in **FIGs 7(A)-(E)**, the connecting rod **71** has a configuration that the top and bottom of the cylinder wall of only
15 the larger diameter hole **711** for receiving eccentric shaft are tapered toward the distal point, resulting in a smaller contact surface with the eccentric shaft.. Unlike the connecting rod **31**, the larger diameter hole is tapered with a curve cut. The gradient of tapering at the top and the bottom are symmetrical. **FIG 7(A)** shows an isometric view of the connecting rod **71** from the bottom; **FIG 7(B)** shows a plan view of the connecting rod **71** from the
20 top; **FIG 7(C)** shows a side view of the connecting rod **71** from the distal part of the larger diameter hole; **FIG 7(D)** shows another side view of the connecting rod **71**; **FIG 7(E)** shows a plan view of the connecting rod **71** from the bottom. As configured, regions on the connecting rod **71** that experience lesser compression load are designed to have a

smaller surface area of contact with the eccentric shaft. Operating force distribution at the corresponding angular position on the connecting rod, such as one exemplifies in **FIG 9(A)**, shall be taken into account in deciding the inner surface area required on the connecting hole.

5 **[0049]** Through the **FIG 9(A)**, it is also to be noted that the operating forced acted on the connecting rod changes in exponentially in a narrower range between the angular positions of 270-405 degrees. Therefore, the reduced inner surface area may also be slightly extended into the angular position range as long as it is configured with a structure having an inner surface that conforms substantially to the corresponding operating load, i.e. at
10 least the corresponding inner surface that operationally experiences relatively high operating load shall preferably to adapted with intended structure with an inner surface area that is able to withstand the operating load.

[0050] In yet further embodiments, the connecting rod may adapt similar configurations as those illustrates above at both the smaller diameter hole and the large diameter hole.

15 **[0051]** It is to be noted that while various embodiments of the connecting rod are provided, the ways to achieve the reduction of contact areas between the connecting rod and its engaging member can be achieved in many possible ways. For example, the top can be tapered and while the bottom defines a step. In addition, the larger diameter hole can have a step and at the same time the smaller diameter hole can be tapered. It is possible to
20 provide markings on the connecting rod to indicate the desired orientation for installation on the assembly.

[0052] One would appreciate that the present invention proposes a solution to reduce contact area between the inner circumferential surface and the eccentric shaft by varying

the inner circumferential surface of the connecting rod based on the operating load distributions, such as the one exemplifies in **FIG 9(A)**. It is understood to a skilled person that the magnitude of force and the degree of angular positions may vary from case to case and they can be determined accordingly for each case. Accordingly, the connecting rod
5 can be fabricated with a non-uniform inner circumferential surface based on the operating load distributions, wherein the surface area that operationally experiences high load is adapted with a relatively larger surface area than the rest of the surface area that experiences lesser load such that it is at least able to withstand the maximum operating load.

10 **[0053]** While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the scope
15 of the present invention. Accordingly, the scope of the present invention is defined by the appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

1. A connecting rod for being used in a reciprocating compressor, the connecting rod comprising:

5 a connecting portion having at least a connecting hole formed at a distal end of the connecting portion,

wherein the connecting hole has an interior surface area that operationally experiencing non-linear operating load across the interior surface area,

10 wherein the non-linear operating load includes a high operating load at a high load region of the interior surface area, the connecting holes are adapted with at least the high load region with a structural strength to withstand the high operating load, and

wherein the interior surface area has a non-uniform height across the surface area adapted based on the non-linear operating load, and the height over the high load region is higher than a region off the high load region.

15 2. The connecting rod of claim 1, wherein the high load region is at a distal part of the connecting hole in relation to the connection portion.

3. The connecting rod of claim 1, wherein the connecting portion has a second connecting hole at another distal end, wherein the second connecting hole has a smaller diameter than that of the connecting hole.

4. The connecting rod of claim 3, wherein an interior surface area of the second connecting hole has a non-uniform height across the surface area, and the height over a high operation load region of the second connecting hole is higher than a region off the high load operating region.
- 5 5. The connecting rod of claim 1, wherein the distal part of the connecting hole is tapered toward the distal point.
6. The connecting rod of claim 5, wherein, when the top and bottom of the connecting hole are tapered, the gradient of tapering on the bottom is different from the one at the top.
7. The connecting rod of claim 1, wherein, when the top and bottom of the connecting
10 hole are tapered, the gradient of tapering on the top symmetrical as the one at the bottom.
8. The connecting rod of claim 1, wherein, when the top and bottom of the connecting hole are tapered, the gradient of tapering at the top is the same as the one at the bottom.
9. The connecting rod of claim 1, further comprising a recession in the top interior surface over at the region off the high load region, resulting the height over the high load
15 region is higher than the remaining region at the connecting hole.
10. The connecting rod of claim 9, further comprising another recession in the bottom interior surface over at the region off the high load region.
11. The connecting rod of claim 10, wherein, when the interior recessions are symmetrical in the top and the bottom.
- 20 12. The connecting rod of claim 10, wherein the interior recession in the bottom is smaller than the one in the top.

wherein the compression unit comprises a connecting rod for connecting an eccentric shaft of the driving unit and a piston pin of a piston in the compression unit so as to convert a rotational force into a rectilinear force; and

5 wherein the connecting portion having at least a connecting hole formed at a distal end of the connecting portion, wherein the connecting hole has an interior surface area that operationally experiencing non-linear operating load across the interior surface area, the non-linear operating load includes a high operating load at a high load region of the interior surface area, the connecting holes are adapted with at least the high load region with a structural strength to withstand the high operating load, wherein the interior surface area
10 has a non-uniform height across the surface area adapted based on the non-linear operating load, and the height over the high load region is higher than a region off the high load region.

19 The reciprocating compressor of claim 18, wherein the smaller diameter hole has an non-uniform height interior surface across the circumferential, the distal end of the interior
15 surface area has a height lower than that of the proximal end in relation to the connecting portion.

20. The reciprocating compressor of claim 19, wherein the distal part of the larger connecting hole is tapered toward the distal point.

21. The reciprocating compressor of claim 20, wherein, when the top and bottom of the
20 connecting hole are tapered, the gradient of tapering at the bottom is symmetrical as the one on the top.

13. The connecting rod of claim 10, wherein the interior recession at the top is smaller than the one on the top.

14. The connecting rod of claim 1, further comprising a step in the top interior surface over at the region off the high load region, resulting the height over the high load region is
5 higher than the region at the connecting hole.

15. The connecting rod of claim 14, further comprising another step in the bottom interior surface over at the region off the high load region.

16. The connecting rod of claim 15, wherein, when the top and bottom interior surface of the connecting hole have the steps, the step at the bottom has a different size from the
10 one on the top.

17 The connecting rod of claim 15, wherein, when the top and the bottom interior surface of the connecting hole have the steps, the step at the bottom is the same as the one on the top.

18. A reciprocating compressor, comprising:

15 a hermetic casing;

a compression unit; and

a driving unit;

wherein the compression unit and the driving unit are installed in the hermetic casing;

22. The reciprocating compressor of claim 20, wherein, when the top and bottom of the connecting hole are tapered, the gradient of tapering at the top is different from the one on the bottom.

23. The reciprocating compressor of claim 19, wherein the distal part of the connecting
5 hole has a recession in the interior surface thereon.

24. The reciprocating compressor of claim 19, wherein, when the top and bottom of the connecting hole have interior recessions, the interior recessions are symmetrical in the top and the bottom.

25. The reciprocating compressor of claim 19, wherein, when the top and bottom of the
10 connecting hole have interior recessions, the interior recession in the bottom has a different size from the one in the top.

26. The reciprocating compressor of claim 19, wherein the distal part of the connecting hole has a step.

27. The reciprocating compressor of claim 19, wherein, when the top and bottom of the
15 connecting hole have steps, the steps are symmetrical at the top and the bottom.

28. The reciprocating compressor of claim 19, wherein, when the top and bottom of connecting hole have steps, the step at the bottom has a different size from the one on the top.