

DESCRIPTION
MECHANICAL SEAL

Technical Field

[0001]

The present invention relates to a mechanical seal and particularly to a mechanical seal which can be split into a radial direction of rotating equipment to which the mechanical seal is attached.

Background Art

[0002]

A mechanical seal has been widely used as shaft sealing means for rotating equipment such as a pump and an agitator and includes a plurality of annular members. Therefore, a part of the rotating equipment requires disassembling to attach or detach the mechanical seal to/from the rotating equipment, whereby the attachment and the detachment work have required a great deal of effort. In order to reduce such effort on the attachment and the detachment work, there has been developed a split mechanical seal in which a component thereof is split into a radial direction of the rotating equipment (refer to Patent Literature 1, for example).

Citation List

Patent Literature

[0003]

Patent Literature 1: JP No. 2002-048248 A

Summary of Invention

Technical Problem

[0004]

When the component of the mechanical seal is split into a radial direction thereof, a slight shift in a shaft direction or a radial direction orthogonal thereto on a split surface would result in imperfect shaft seal, which makes it easier for oil, water or the like to leak. In the case of the mechanical seal disclosed in Patent Literature 1, the shift in the shaft direction and the radial direction on each split cross section of a sleeve and a gland cover is prevented by inserting a pin called an alignment pin into a hole formed on each split cross section perpendicularly thereto. However, a shift equivalent to a clearance required between the pin and the hole occurs on each split cross section, and a shift equivalent to the shift on the split cross section also occurs in a half-split slide member attached to the sleeve and the gland cover, thereby causing the leakage problem.

[0005]

An object of the present invention is to solve the aforementioned problems, that is, to decrease the shift on the

split cross section of the mechanical seal.

Solution to Problem

[0006]

A mechanical seal in an embodiment of the present invention provided to achieve the aforementioned object includes at least: a rotary ring which rotates while driven by a rotating shaft of rotating equipment; a seal ring which is brought into contact with the rotary ring in a shaft direction of the rotating shaft; and a gland cover which is in a sealed state with the seal ring to cover an outer side thereof. At least the rotary ring, the seal ring, and the gland cover are split into a radial direction thereof, where one surface of a split surface of at least the gland cover includes a projection which is projected toward another surface of the split surface while the other surface includes a recess which is fitted to the projection.

[0007]

The mechanical seal in another embodiment of the present invention further includes a sleeve which rotates while driven by the rotating shaft and covers an outer side of the rotary ring while in a sealed state therewith. One surface of a split surface of the sleeve includes a projection which is projected toward another surface of the split surface, while the other surface includes a recess which is fitted to the projection.

[0008]

In another embodiment of the present invention, the projection in the mechanical seal has an anisotropic form extending long in any direction within a plane of the split surface, while the recess has an anisotropic form to be fitted to the anisotropic projection.

[0009]

The mechanical seal in another embodiment of the present invention further includes a plurality of the anisotropic projections which includes: a first projection extending long along the shaft direction of the rotating shaft; and a second projection extending long along the radial direction of the rotating shaft. The anisotropic recess includes: a first recess which is fitted to the first projection and extends long along the shaft direction of the rotating shaft; and a second recess which is fitted to the second projection and extends long along the radial direction of the rotating shaft.

[0010]

The mechanical seal in another embodiment of the present invention further includes two of the recesses which are provided on the split surfaces facing each other, respectively, and extend long in the same direction on the both split surfaces, where a pin forming the projection is embedded in one of the two recesses, and another recess of the two recesses is fitted to an exposed surface of the pin when the split surfaces are brought together.

[0011]

In the mechanical seal in another embodiment of the present invention, the pin is fixed such that more than half the volume thereof is embedded in the one recess.

[0012]

The mechanical seal in another embodiment of the present invention further includes two pre-assemblies each including a rotary ring half, a seal ring half, and a gland cover half which are formed by splitting at least the rotary ring, the seal ring, and the gland cover, respectively, into the respective radial directions.

[0013]

The mechanical seal in another embodiment of the present invention further includes a coat layer formed of a fluorine-based resin on the one surface of the split surfaces, and an elastic adhesive layer stacked on the coat layer on the other surface of the split surfaces, whereby the elastic adhesive layer is interposed between the coat layers when the split surfaces are brought together.

Advantageous Effects of Invention

[0014]

According to the present invention, the shift in the split cross section of the mechanical seal can be decreased.

Brief Description of Drawings

[0015]

Fig. 1 is an exploded perspective view in which a mechanical seal according to a first embodiment of the present invention is partially disassembled.

Fig. 2 is an exploded perspective view in which a pre-assembly constituting the mechanical seal illustrated in Fig. 1 is disassembled.

Fig. 3 is a side view of a pre-assembly which is illustrated in Fig. 1 and seen from a split surface side.

Fig. 4 is a front view of the mechanical seal which is illustrated in Fig. 1 and seen from an atmosphere side toward an equipment side.

Fig. 5 is an enlarged perspective view of a projection which is formed in a sleeve half illustrated in Fig. 2.

Fig. 6 is a diagram illustrating the vicinity of the projection illustrated in Fig. 5 from the equipment side.

Fig. 7 is a set of diagrams illustrating a state before and after moving a set screw to the atmosphere side and before and after detaching a preset chip during the installation work of the mechanical seal.

Fig. 8 is an enlarged perspective view of a projection formed in a sleeve half of the mechanical seal according to a second embodiment.

Fig. 9 is an enlarged perspective view of a projection formed in a sleeve half of the mechanical seal according to a third

embodiment.

Reference Signs List

[0016]

1	mechanical seal
1a, 1b	pre-assembly
2	sleeve
2a, 2b	sleeve half
3	rotary ring
3a, 3b	rotary ring half
4	seal ring
4a, 4b	seal ring half
5	gland cover
5a, 5b	gland cover half
18	split surface
40, 42	second recess (recess)
41, 43	first recess (recess)
50, 52	second projection (projection)
51, 53	first projection (projection)
58	split surface
70, 72	second recess (recess)
71, 73	first recess (recess)
80, 82	second projection (projection)
81, 83	first projection (projection)
150	drape pin (pin)

151 drape pin (pin)
170 recess
171 projection
180 projection
B rotating shaft

Description of Embodiments

[0017]

Each embodiment of a mechanical seal according to the present invention will now be described with reference to the drawings.

[0018]

<First embodiment>

Fig. 1 is an exploded perspective view in which a mechanical seal according to a first embodiment of the present invention is partially disassembled. Fig. 2 is an exploded perspective view in which a pre-assembly constituting the mechanical seal illustrated in Fig. 1 is disassembled. Fig. 3 is a side view of the pre-assembly which is illustrated in Fig. 1 and seen from a split surface side. Fig. 4 is a front view of the mechanical seal which is illustrated in Fig. 1 and seen from an atmosphere side toward an equipment side.

[0019]

1. Schematic overall structure of mechanical seal

A mechanical seal 1 according to the first embodiment

includes at least: a rotary ring 3 which rotates while driven by a rotating shaft B of rotating equipment (hereinafter simply referred to as "equipment" as well); a sleeve 2 which rotates while driven by the rotating shaft B and covers an outer side of the rotary ring 3 while in a sealed state therewith; a seal ring 4 which is brought into contact with the rotary ring 3 in a shaft direction of the rotating shaft B; a gland cover 5 which is in a sealed state with the seal ring 4 to cover an outer side thereof; and two pre-assemblies 1a and 1b formed by splitting at least the rotary ring 3, the sleeve 2, the seal ring 4, and the gland cover 5 into a radial direction of the rotating shaft B. Both of the two pre-assemblies 1a and 1b constituting the mechanical seal 1 have a split surface that can be joined together when the pre-assemblies are installed to the rotating shaft B. The mechanical seal 1 includes O-rings 6 to 9 in addition to the sleeve 2, the rotary ring 3, the seal ring 4, and the gland cover 5. The O-rings 6 to 9 are split into the radial direction thereof as well. As a result, the pre-assembly 1a includes a sleeve half 2a, a rotary ring half 3a, a seal ring half 4a, a gland cover half 5a, and O-ring halves 6a to 9a, while the pre-assembly 1b includes a sleeve half 2b, a rotary ring half 3b, a seal ring half 4b, a gland cover half 5b, and O-ring halves 6b to 9b. The pre-assemblies 1a and 1b are not always necessary, accordingly the sleeve half 2a, the rotary ring half 3a, the seal ring half 4a, and the gland cover half 5a, or the sleeve half 2b, the rotary ring half 3b, the seal ring half

4b, and the gland cover half 5b, respectively, need not be integrated.

[0020]

2. Overview of each component

2.1 Sleeve (sleeve half 2a and sleeve half 2b)

The sleeve 2 has a substantially cylindrical shape. Both end sides of a longitudinal direction of the sleeve 2 are made larger in a radial direction, and a space 10 is provided in a roughly central area of the sleeve 2 in the shaft direction to arrange therein the rotary ring 3, the seal ring 4, and the gland cover 5. The sleeve 2 is a rotating ring which rotates while attached to and driven by the rotating shaft B. In the present embodiment, the sleeve 2 is a component formed of metal (preferably SUS). The sleeve 2 includes, on one surface of both split surfaces 18 and 18, projections 50 to 53 which are projected toward another surface of the both split surfaces 18 and 18 and includes, on the other surface of the both split surfaces 18 and 18, recesses 40 to 43 which are fitted to the projections 50 to 53. The "fitted" here refers to an engaged state in which the projection and the recess are in close contact with each other with hardly any clearance therebetween. Numerically, the clearance between the projections 50 to 53 and the recesses 40 to 43 is 5 μm or less, preferably 3 μm or less, or more preferably 0 μm .

[0021]

2.2 Rotary ring (rotary ring half 3a and rotary ring half 3b)

The rotary ring 3 has a substantially cylindrical shape. The rotary ring 3 is a rotating ring which rotates while driven by the rotating shaft B and is attached to a position closest to the equipment side within the space 10 of the sleeve 2. In the present embodiment, the rotary ring 3 is a component formed of silicon carbide, for example.

[0022]

2.3 Seal ring (seal ring half 4a and seal ring half 4b)

The seal ring 4 has a cylindrical shape in which one end thereof has a larger diameter to serve as a flange. The seal ring 4 is a floating ring not driven by the rotating shaft B and is attached to a position in contact with the rotary ring 3 within the space 10. In the present embodiment, the seal ring 4 is a component formed of carbon, for example. The seal ring 4 is made smaller than the rotary ring 3 in the present embodiment but may be made larger as well.

[0023]

2.4 Gland cover (gland cover half 5a and gland cover half 5b)

The gland cover 5 has a substantially cylindrical shape that is short in a longitudinal direction. The gland cover 5 is fixed to the equipment while a part of the gland cover is inserted into the space 10 to adjoin the seal ring 4 through the O-ring 8. In the present embodiment, the gland cover 5 is a component formed of metal (preferably SUS). The gland cover 5 includes, on one surface of both split surfaces 58 and 58, projections 80 to 83

which are projected toward another surface of the both split surfaces 58 and 58 and includes, on the other surface of the both split surfaces 58 and 58, recesses 70 to 73 which are fitted to the projections 80 to 83. The clearance between the projections 80 to 83 and the recesses 70 to 73 is 10 μm or less, preferably 3 μm or less, or more preferably 0 μm .

[0024]

2.5 O-ring (O-ring halves 6a to 9a and O-ring halves 6b to 9b)

The O-ring 6 is a sealing ring arranged between an inner surface of the sleeve 2 and the rotating shaft B. The O-ring 7 is a sealing ring arranged between an outer surface of the rotary ring 3 and an inner surface of an outer wall of the sleeve 2 covering the rotary ring 3. Two pieces of the O-ring 7 are arranged along a longitudinal direction of the rotary ring 3. The O-ring 7 functions as a stopper to prevent the rotary ring 3 from rotating in the sleeve 2. The processing man-hour can be reduced by using the two O-rings 7 as compared to the case where a metal pin or the like is used to prevent the rotation. It is also feasible to arrange a single piece of the O-ring 7 so that a pin is used to prevent the rotation of the rotary ring 3 and the sleeve 2. The O-ring 8 is a sealing ring arranged between an outer surface of the seal ring 4 and the gland cover 5. The O-ring 9 is a sealing ring arranged between the gland cover 5 and the equipment. In the present embodiment, the O-rings 6 to 9 are formed of fluorine-based elastomer, for example.

[0025]

The aforementioned components are assembled into the mechanical seal 1 which is then attached to the rotating shaft B of the equipment, whereby the sleeve 2 and the rotary ring 3 would rotate along with the rotating shaft B. The gland cover 5 being fixed to the equipment would not move. The seal ring 4 being interposed between the gland cover 5 and the rotary ring 3 and not being fixed to the rotary ring 3 or the sleeve 2 would move freely in the shaft direction while in a sliding state with the rotary ring 3.

[0026]

3. Detailed structure of mechanical seal

3.1 Structure of sleeve

As illustrated in Fig. 1, the sleeve half 2a includes a notch 11 formed by cutting off a part of the sleeve half into a square shape in a circumferential direction near the split surface 18 on the atmosphere side. The sleeve half 2b likewise includes a notch 11 at a position having in-plane symmetry with the aforementioned notch 11 about the center of the sleeve 2. The notch 11 includes a through-hole 12 passing through the sleeve 2 toward the split surface 18. The sleeve halves 2a and 2b include screw holes 13 and 13 with a groove in the interior thereof, respectively, on the one split surfaces 18 at a position corresponding with the through-holes 12 and 12 on the other split surfaces 18. The sleeve half 2a also includes a notch 15 formed

by cutting off a part of the sleeve half in the circumferential direction into a square shape near the split surface 18 on the equipment side. The sleeve half 2b likewise includes a notch 15 at a position having in-plane symmetry with the aforementioned notch 15 about the center of the sleeve 2. The notch 15 includes a through-hole 16 passing through the sleeve 2 toward the split surface 18. The sleeve halves 2a and 2b include screw holes 17 and 17 with a groove in the interior thereof, respectively, on the one split surfaces 18 at a position corresponding with the through-holes 16 and 16 on the other split surfaces 18. The sleeve half 2a and the sleeve half 2b are assembled together by screwing a bolt 20 to the screw holes 13 and 13 through the through-holes 12 and 12, and to the screw holes 17 and 17 through the through-holes 16 and 16, respectively.

[0027]

Each of the sleeve halves 2a and 2b includes two screw holes 21 and 21 along the outer circumference of the sleeve half from each of the notches 11 and 11. Each screw hole 21 passes through the inside of each of the sleeve halves 2a and 2b such that a screw 25 can be screwed to a position in contact with the rotating shaft B. The sleeve 2 can be fixed to the rotating shaft B by screwing the screw 25 in the screw hole 21 to the position in contact with the rotating shaft B. Another screw hole 28 is formed adjacent to the screw hole 21 in the circumferential direction. The screw hole 28 does not reach inside each of the sleeve halves 2a and

2b but is used to temporarily fix a preset chip 120 in assembling the pre-assemblies 1a and 1b together. The preset chip 120 is an adjusting member to align the centers of the sleeve 2 and the gland cover 5. Four pieces of the preset chip are provided in the present embodiment. The preset chip 120 includes a through-hole 121 through which a bolt 130 is inserted to be screwed into the screw hole 28 and align the centers.

[0028]

Each of the sleeve halves 2a and 2b includes three through-holes 32 passing through the thickness direction of the flange part with the enlarged diameter formed on the atmosphere side. The sleeve halves 2a and 2b also include grooves 26 and 26, respectively, formed on the inner surface of each of the sleeve halves along the circumference thereof. The grooves 26 and 26 are provided to fix the O-ring halves 6a and 6b and are opened at the side of the rotating shaft B.

[0029]

As illustrated in Figs. 2 and 3, the recesses 42 and 43 are provided on the one surface of the sleeve half 2a holding the rotating shaft B on the equipment side. The recess 43 extends along the shaft direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the recess 42 from the end face of the sleeve half 2a on the equipment side toward the side of the rotary ring half 3a. The recess 43 will hereinafter be

specifically referred to as a "first recess 43" when it is to be mentioned individually. The recess 42 extends along the radial direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered from the outer surface of the sleeve half 2a toward the inner side of the rotating shaft B in the radial direction thereof. The recess 42 will hereinafter be specifically referred to as a "second recess 42" when it is to be mentioned individually. The first recess 43 and the second recess 42 are formed not in contact with each other.

[0030]

On the other hand, the projections 50 and 51 are provided on the other surface of the sleeve half 2a holding the rotating shaft B on the equipment side. The projection 51 extends along the shaft direction of the rotating shaft B and has a half columnar shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the projection 50 from the end face of the sleeve half 2a on the equipment side toward the side of the rotary ring half 3a. The projection 51 will hereinafter be specifically referred to as a "first projection 51" when it is to be mentioned individually. The projection 50 extends along the radial direction of the rotating shaft B and has a half columnar shape (an example of the anisotropic form) which is tapered from the outer surface of the sleeve half 2a toward the inner side of the rotating shaft B in the radial direction thereof. The

projection 50 will hereinafter be specifically referred to as a "second projection 50" when it is to be mentioned individually. The first projection 51 and the second projection 50 are formed not in contact with each other.

[0031]

As illustrated in Fig. 1, the sleeve half 2b includes the recess 41 and the recess 40 in the form and the position to be fitted with the first projection 51 and the second projection 50 of the sleeve half 2a, respectively. The recess 41 extends along the shaft direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the recess 40 from the end face of the sleeve half 2b on the equipment side toward the side of the rotary ring half 3b. The recess 41 will hereinafter be specifically referred to as a "first recess 41" when it is to be mentioned individually. The recess 40 extends along the radial direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered from the outer surface of the sleeve half 2b toward the inner side of the rotating shaft B in the radial direction thereof. The recess 40 will hereinafter be specifically referred to as a "second recess 40" when it is to be mentioned individually. The first recess 41 and the second recess 40 are formed not in contact with each other.

[0032]

Moreover, the sleeve half 2b includes the projection 53 and the projection 52 in the form and the position to be fitted with the first recess 43 and the second recess 42 of the sleeve half 2a, respectively. The projection 53 extends along the shaft direction of the rotating shaft B and has a half columnar shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the projection 52 from the end face of the sleeve half 2b on the equipment side toward the side of the rotary ring half 3b. The projection 53 will hereinafter be specifically referred to as a "first projection 53" when it is to be mentioned individually. The projection 52 extends along the radial direction of the rotating shaft B and has a half columnar shape (an example of the anisotropic form) which is tapered from the outer surface of the sleeve half 2b toward the inner side of the rotating shaft B in the radial direction thereof. The projection 52 will hereinafter be specifically referred to as a "second projection 52" when it is to be mentioned individually. The first projection 53 and the second projection 52 are formed not in contact with each other.

[0033]

All the projections 50 to 53 and all the recesses 40 to 43 having the same form in the present embodiment, respectively, need not have the same form. That is, the projections 50 to 53 among themselves or the recesses 40 to 43 among themselves need not have the same form as long as the projections 50 to 53 can be fitted

with the opposing recesses 40 to 43.

[0034]

It is preferred that the projections 50 to 53 be joined to the recesses 40 to 43 on both sides of the sleeve 2 while interposing the rotating shaft B. However, it is also possible to only form the set of the projections 50 and 51 and the recesses 40 and 41 on the both split surfaces 18 and 18 of the sleeve 2, and not form the set of the projections 52 and 53 and the recesses 42 and 43. Moreover, it is possible to only form the set of the projection 50 and the recess 40 and the set of the projection 53 and the recess 43 on the both split surfaces 18 and 18 of the sleeve 2. Furthermore, it is possible to only form the set of the projection 51 and the recess 41 and the set of the projection 52 and the recess 42 on the both split surfaces 18 and 18 of the sleeve 2. That is, the combination of the projection and the recess is unrestricted as long as a stopper can be formed for both the shaft direction and the radial direction in order to prevent the sleeve halves 2a and 2b from shifting in both the shaft direction and the radial direction of the rotating shaft B. Accordingly, the clearance between the projections 50 to 53 and the recesses 40 to 43 can be nearly eliminated so that the shift between the split surfaces 18 and 18 can be reduced more reliably than the configuration in which the pin or the like is removably inserted between the both split surfaces 18 and 18 of the sleeve halves 2a and 2b.

[0035]

3.2 Structure of gland cover

As illustrated in Fig. 1, the gland cover half 5a includes, on the circumferential side surface thereof, a notch 60 formed by cutting off a part of the gland cover half into a square shape in the circumferential direction near the split surface 58. The gland cover half 5b likewise includes a notch 60 at a position symmetrical with the aforementioned notch 60 about the center of the gland cover 5. The notch 60 includes a through-hole 61 passing through the gland cover 5 toward the split surface 58. The gland cover halves 5a and 5b include screw holes 62 and 62 with a groove in the interior thereof, respectively, on the one split surfaces 58 at a position corresponding with the through-holes 61 and 61 on the other split surfaces 58. The gland cover half 5a and the gland cover half 5b are assembled together by screwing bolts 65 and 65 to the screw holes 62 and 62 through the through-holes 61 and 61, respectively.

[0036]

As illustrated in Figs. 2 and 3, the gland cover half 5a includes the recesses 70 and 71 at a position closer to the atmosphere side than the through-hole 61 on the one surface of the split surfaces 58 interposing the rotating shaft B. The recess 71 extends along the shaft direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the recess

70 from the end face of the gland cover half 5a on the atmosphere side toward the equipment side. The recess 71 will hereinafter be specifically referred to as a "first recess 71" when it is to be mentioned individually. The recess 70 extends along the radial direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered from the outer surface of the gland cover half 5a toward the inner side of the rotating shaft B in the radial direction thereof. The recess 70 will hereinafter be specifically referred to as a "second recess 70" when it is to be mentioned individually. The first recess 71 and the second recess 70 are formed not in contact with each other.

[0037]

On the other hand, the gland cover half 5a includes the projections 83 and 82 at a position closer to the atmosphere side than the screw hole 62 on the other surface of the split surfaces 58 interposing the rotating shaft B. The projection 83 extends along the shaft direction of the rotating shaft B and has a half columnar shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the projection 82 from the end face of the gland cover half 5a on the atmosphere side toward the equipment side. The projection 83 will hereinafter be specifically referred to as a "first projection 83" when it is to be mentioned individually. The projection 82 extends along the radial direction of the rotating shaft B and has a half columnar

shape (an example of the anisotropic form) which is tapered from the outer surface of the gland cover half 5a toward the inner side of the rotating shaft B in the radial direction thereof. The projection 82 will hereinafter be specifically referred to as a "second projection 82" when it is to be mentioned individually. The first projection 83 and the second projection 82 are formed not in contact with each other.

[0038]

As illustrated in Fig. 1, the gland cover half 5b includes the recesses 72 and 73 at a position closer to the atmosphere side than the through-hole 61 on the one surface of the split surfaces 58 interposing the rotating shaft B. The recess 73 extends along the shaft direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the recess 72 from the end face of the gland cover half 5b on the atmosphere side toward the equipment side. The recess 73 will hereinafter be specifically referred to as a "first recess 73" when it is to be mentioned individually. The recess 72 extends along the radial direction of the rotating shaft B and has a half cylindrical shape (an example of the anisotropic form) which is tapered from the outer surface of the gland cover half 5b toward the inner side of the rotating shaft B in the radial direction thereof. The recess 72 will hereinafter be specifically referred to as a "second recess 72" when it is to be mentioned individually. The first recess 73 and

the second recess 72 are formed not in contact with each other.

[0039]

On the other hand, the gland cover half 5b includes the projections 80 and 81 at a position closer to the atmosphere side than the screw hole 62 on the other surface of the split surfaces 58 interposing the rotating shaft B. The projection 81 extends along the shaft direction of the rotating shaft B and has a half columnar shape (an example of the anisotropic form) which is tapered in a direction orthogonal to the projection 80 from the end face of the gland cover half 5b on the atmosphere side toward the equipment side. The projection 81 will hereinafter be specifically referred to as a "first projection 81" when it is to be mentioned individually. The projection 80 extends along the radial direction of the rotating shaft B and has a half columnar shape (an example of the anisotropic form) which is tapered from the outer surface of the gland cover half 5b toward the inner side of the rotating shaft B in the radial direction thereof. The projection 80 will hereinafter be specifically referred to as a "second projection 80" when it is to be mentioned individually. The first projection 81 and the second projection 80 are formed not in contact with each other.

[0040]

All the projections 80 to 83 and all the recesses 70 to 73 having the same form in the present embodiment, respectively, need not have the same form. The projections 80 to 83 among themselves

or the recesses 70 to 73 among themselves need not have the same form as long as the projections 80 to 83 can be fitted with the opposing recesses 70 to 73.

[0041]

It is preferred that the projections 80 to 83 be joined to the recesses 70 to 73 on both sides of the gland cover 5 while interposing the rotating shaft B. However, it is also possible to only form the set of the projections 82 and 83 and the recesses 72 and 73 on the both split surfaces 58 and 58 of the gland cover 5, and not form the set of the projections 80 and 81 and the recesses 70 and 71. Moreover, it is possible to only form the set of the projection 82 and the recess 72 and the set of the projection 81 and the recess 71 on the both split surfaces 58 and 58 of the gland cover 5. Furthermore, it is possible to only form the set of the projection 83 and the recess 73 and the set of the projection 80 and the recess 70 on the both split surfaces 58 and 58 of the gland cover 5. That is, the combination of the projection and the recess is unrestricted as long as a stopper can be formed for both the shaft direction and the radial direction in order to prevent the gland cover halves 5a and 5b from shifting in both the shaft direction and the radial direction of the rotating shaft B. Accordingly, the clearance between the projections 80 to 83 and the recesses 70 to 73 can be nearly eliminated so that the shift between the split surfaces 58 and 58 can be reduced more reliably than the configuration in which the pin or the like is removably

inserted between the both split surfaces 58 and 58 of the gland cover halves 5a and 5b.

[0042]

Each of the gland cover halves 5a and 5b includes two through-holes 90 passing through the thickness direction of the gland cover halves. The through-hole 90, into which a bolt 96 illustrated in Fig. 4 is inserted, is required to fix the gland cover 5 to a stuffing box T of the equipment. The gland cover half 5b (or 5a) includes a drain hole (with a diameter of approximately 4 mm) 95 obliquely passing through the gland cover half from the surface thereof on the opposite side of the equipment toward the seal ring 4b. The drain hole 95 is a through-hole provided to discharge the leakage of water, oil or the like to the outside.

[0043]

As illustrated in Fig. 2, the gland cover halves 5a and 5b include, on the surface thereof on the equipment side, grooves 66 and 66 formed along the circumferential direction of the rotating shaft B. The grooves 66 and 66 are provided to fix the O-ring halves 9a and 9b and are open on the equipment side. The gland cover halves 5a and 5b also include, on the surface thereof on the side of the rotating shaft B, grooves 68 and 68 formed along the circumferential direction of the rotating shaft B. The grooves 68 and 68 are provided to fix the O-ring halves 8a and 8b and are open on the rotating shaft B side.

[0044]

Each of the gland cover halves 5a and 5b includes three screw holes 132 disposed in the circumferential direction on the inner side of the through-hole 90 along the radial direction. The screw hole 132 passes through the gland cover halves 5a and 5b in the thickness direction thereof. A groove is formed inside the screw hole 132 so that a set screw 140 can be moved to be both inserted and removed. The set screw 140 is used to push the rotary ring 3 from the seal ring 4 side in order to fix the rotary ring 3 tightly to the sleeve 2. The set screw 140 prevents a flatness error of the rotary ring 3 and the seal ring 4 and has a function to prevent each component from falling out when the pre-assemblies 1a and 1b are split. After the mechanical seal 1 is installed to the equipment, the set screw 140 is either pulled out or moved in a pull-out direction to release the pressing force against the seal ring 4. The set screw 140 is mainly formed of SUS, while only a tip of the set screw on the side in contact with the seal ring 4 is formed of metal softer than the SUS (such as copper). Therefore, the seal ring 4 would not be easily damaged even when the set screw 140 comes in contact with the seal ring 4.

[0045]

The gland cover 5 includes two pins 145 and 12 springs 146 in a gap formed with the seal ring 4 so that the seal ring 4 is biased to the side of the rotary ring 3.

[0046]

3.3 Structure of rotary ring

As illustrated in Fig. 2, the rotary ring half 3a includes two grooves 101 and 101 arranged side by side in the thickness direction along the outer circumference of the rotary ring half. Each groove 101 is provided to fix each of the O-ring halves 7a and 7b and is open on the side of the sleeve halves 2a and 2b. Moreover, the rotary ring halves 3a and 3b include, on the end face thereof on the side of the seal ring halves 4a and 4b, a projected surface 102 projected toward the side of the seal ring halves 4a and 4b. The projected surface 102 and the seal ring halves 4a and 4b are brought into contact with each other to form a sliding part S therebetween (refer to Fig. 3).

[0047]

3.4 Structure of seal ring

As illustrated in Fig. 2, each of the seal ring halves 4a and 4b is a component having a substantially L-shaped cross section and includes: a flange part 111 having a larger diameter on the side of the rotary ring halves 3a and 3b; and a sleeve part 112 connected to the flange part 111 and extending to the side of the gland cover halves 5a and 5b. The end face of the sleeve part 112 on the side of the gland cover halves 5a and 5b comes in contact with the aforementioned pin 145 and the tip of the set screw 140. The sleeve part 112 also includes on the inner surface thereof a groove 115 which is opened on the end surface of the sleeve part on the side of the gland cover halves 5a and 5b and has a half

cylindrical shape. The aforementioned pin 145 is brought into contact with the groove 115 to prevent the seal ring 4 from rotating.

[0048]

3.5 Structure of projection and recess formed on each split surface of sleeve and gland cover

[0049]

Fig. 5 is an enlarged perspective view of the projection which is formed in the sleeve half illustrated in Fig. 2. Fig. 6 is a diagram illustrating the vicinity of the projection illustrated in Fig. 5 from the equipment side.

[0050]

The sleeve half 2a constituting the sleeve 2 includes on the split surface 18 the second recess 40 and the first recess 41 identical to those in the sleeve half 2b. Embedded in the second recess 40 on the sleeve half 2a side is a pin (such as a pin formed of SUS, which will be referred to as a "drape pin") 150 having a substantially columnar shape and forming the second projection 50. When the sleeve half 2a and the sleeve half 2b are joined together, the exposed surface of the drape pin 150 would be fitted to the second recess 40 on the sleeve half 2b side. Likewise, a drape pin 151 forming the first projection 51 is embedded in the first recess 41 on the sleeve half 2a side. When the sleeve half 2a and the sleeve half 2b are joined together, the exposed surface of the drape pin 151 would be fitted to the first recess

41 on the sleeve half 2b side.

[0051]

The drape pins 150 and 151 are driven into a hole (with a diameter slightly smaller than the outer diameter of the drape pin 150) formed of the two second recesses 40 and a hole (with a diameter slightly smaller than the outer diameter of the drape pin 151) formed of the two first recesses 41, respectively, the holes being formed when the sleeve half 2a and the sleeve half 2b are joined together. When the sleeve half 2a and the sleeve half 2b are thereafter separated from each other, the drape pins 150 and 151 would remain in the sleeve half 2a. As a result, the drape pins 150 and 151 remaining in the sleeve half 2a would form the second projection 50 and the first projection 51, respectively. Here, the first recess 41 and the second recess 40 formed in the sleeve half 2a have a greater capacity than the first recess 41 and the second recess 40 formed in the sleeve half 2b, respectively. Accordingly, as illustrated in Fig. 6, an area 151a having more than half the volume of the drape pin 151 would be embedded into the first recess 41 on the sleeve half 2a side when the drape pin 151 is driven into the hole formed of the two first recesses 41. On the other hand, an area 151b having less than half the volume of the drape pin 151 would be embedded into the sleeve half 2b side. As a result, the drape pin 151 can be reliably fixed into the sleeve half 2a side while being embedded therein without coming off when the sleeve half 2a and the sleeve half 2b are separated

from each other. The same can be said for the case where the drape pin 150 is driven into the second recess 40. It is also possible to form the first recess 41 or the second recess 40 deeper on the sleeve half 2b side and shallower on the sleeve half 2a side so that the drape pins 150 and 151 would remain on the sleeve half 2b side. The clearance between the second projection 50 formed of the drape pin 150 and the matching second recess 40, and between the first projection 51 formed of the drape pin 151 and the matching first recess 41 would be 10 μm or less, preferably 3 μm or less, or more preferably 0 μm .

[0052]

The same structure is applied to the second recess 42 and the first recess 43. Moreover, the second projection 52 and the first projection 53 are formed in the same manner as what is described above. Furthermore, the same structure is applied to the first recesses 71 and 73, the second recesses 70 and 72, the first projections 81 and 83, and the second projections 80 and 82 which are formed in the gland cover 5. A drape pin other than the drape pins 150 and 151 will hereinafter be referred to as the "drape pin 150 or the like" without assigning a reference numeral individually.

[0053]

3.6 Coat treatment on split surface

It is preferred that the sleeve 2 and the gland cover 5 have a coat layer formed of a fluorine-based resin on one of the

respective split surfaces 18 and 58 in order to enhance the sealing property on the split surface of the mechanical seal 1. By forming the coat layer and an elastic adhesive layer stacked thereon on the other surface of the respective split surfaces 18 and 58, the elastic adhesive layer can be interposed between the coat layers when the two pre-assemblies 1a and 1b are assembled together. It is preferred that the elastic adhesive layer be able to retain the adhesive feature for an extended period of time while repeating the disassembly and the assembly of the pre-assemblies 1a and 1b. The thickness of the coat layer is preferably 0.1 to 40 μm , more preferably 0.1 to 30 μm , and most preferably 0.1 to 10 μm . The elastic adhesive layer is an adhesive layer preferably formed of a urethane resin. The contact between rubber packing which has been used conventionally and the O-ring can be eliminated by using the coat layer and the elastic adhesive layer, whereby water or the like would not leak easily. Note that the coat layer may only be formed on each split surface 18 of the sleeve halves 2a and 2b or each split surface 58 of the gland cover halves 5a and 5b. There is an advantage of having the coat layer formed of the fluorine-based resin that the elastic adhesive layer comes off easily to be used for a number of times.

[0054]

4. Method of assembling mechanical seal

Now, the assembling of the pre-assemblies 1a and 1b and the subsequent installation thereof to the equipment, in a method of

assembling the mechanical seal 1 according to the first embodiment, will be described separately.

[0055]

4.1 Assembling of pre-assembly

The assembling process is performed as follows.

- 1) The fluorine-based resin is applied to each split surface 18 of the sleeve halves 2a and 2b to form the coat layer, and the urethane-based adhesive is applied onto the coat layer on the sleeve half 2a side to form the elastic adhesive layer.
- 2) The sleeve halves 2a and 2b are integrated by using the bolt 20.
- 3) The drape pin 150 or the like is driven into the hole formed by each set of the recesses 40 to 43.
- 4) The O-ring halves 6a and 6b are attached to the groove 26 in the sleeve 2.
- 5) Two sets of the O-ring halves 7a and 7b are attached to the two grooves 101 and 101 in each of the rotary ring halves 3a and 3b, respectively.
- 6) The rotary ring halves 3a and 3b are inserted and attached to the sleeve 2.

The assembling of the rotating ring will be completed by performing the processes up to this point.

[0056]

- 7) The fluorine-based resin is applied to each split surface 58 of the gland cover halves 5a and 5b to form the coat layer, and

the urethane-based adhesive is applied onto the coat layer on the gland cover half 5a side to form the elastic adhesive layer.

8) The gland cover halves 5a and 5b are integrated by using the bolt 65.

9) The drape pin 150 or the like is driven into the hole formed by each set of the recesses 70 to 73.

10) The O-ring halves 8a and 8b are attached to the groove 68 in the gland cover 5.

11) The O-ring halves 9a and 9b are attached to the groove 66 in the gland cover 5.

12) The spring 146 and the pin 145 are attached to the gland cover 5.

13) The seal ring halves 4a and 4b are inserted to the gland cover 5.

The assembling of the seal ring 4 and the gland cover will be completed by performing the processes up to this point.

[0057]

14) The bolt 65 is unscrewed to split the gland cover 5.

15) The seal ring halves 4a and 4b and the gland cover halves 5a and 5b are inserted to the rotating ring assembly from an outer circumference thereof.

16) The bolt 65 is used again to integrate the gland cover 5.

17) The preset chip 120 is fixed to the sleeve 2 by using the bolt 130.

18) The set screw 140 is screwed to press the seal ring 4 and the

rotary ring 3 against the sleeve 2.

The pre-assemblies 1a and 1b will be made into a cartridge by performing the processes up to this point.

[0058]

4.2 Installation of mechanical seal to equipment

- 1) The mechanical seal 1, from which the bolts 20 and 65 are unscrewed, is split into the pre-assemblies 1a and 1b.
- 2) The pre-assemblies 1a and 1b are fitted to the rotating shaft B of the equipment so that the sleeve 2 is integrated by using the bolt 20.
- 3) The bolt 65 is used to integrate the gland cover 5. Here, in a conventional complete half seal, a number of components have had to be installed one by one at the site, thereby having required a great amount of operation time, made it difficult to accurately assemble two slide members, and resulted in the leakage in some cases. In the present mechanical seal 1, however, the pre-assembly is integrated along the shaft direction so that all the component halves can be simultaneously integrated with high accuracy, whereby the risk of the leakage is reduced.
- 4) The bolt 96 is used to fix the mechanical seal 1 to the equipment (particularly to the stuffing box T of the equipment). At this time, the centers for each of the gland cover 5 and the sleeve 2 have already been aligned by the preset chip 120, thereby requiring no operation to align the centers afresh.
- 5) The sleeve 2 is fixed to the rotating shaft B by using the screw

25. At this time, the positional relationship between the gland cover 5 and the sleeve 2 in the shaft direction has already been kept at a correct set position by the preset chip 120 with the spring having a regular compressed length, thereby requiring no measurement or adjustment of the set position as is performed in the conventional mechanical seal.

6) The set screw 140 is moved to the atmosphere side to release the pressing force against the seal ring 4. 7) The bolt 130 is unscrewed to detach the preset chip 120 from the sleeve 2.

[0059]

Fig. 7 is a set of diagrams illustrating a state before and after moving the set screw to the atmosphere side and before and after detaching the preset chip during the installation work of the mechanical seal.

[0060]

A hatched area represents the set screw 140, the bolt 130, and the preset chip 120. As illustrated in Fig. 7, a jig (such as an L-shaped hexagonal wrench) is inserted from the through-hole 32 so that the set screw 140 is moved in a direction indicated by an arrow (the atmosphere side direction) to release the pressing force against the seal ring 4. In the stage of making the pre-assemblies 1a and 1b into the cartridge, a part of the preset chip 120 is inserted in a gap W formed between the gland cover 5 and the sleeve 2. The preset chip 120 has a function to align the centers for the sleeve 2 and the gland cover 5 by screwing

the bolt 130 and to secure the gap W. Once the mechanical seal 1 is attached to the equipment, the preset chip 120 having fulfilled the role thereof is detached before the equipment is operated. The installation of the mechanical seal 1 will be completed by performing the processes up to this point.

[0061]

<Second embodiment>

A mechanical seal according to a second embodiment of the present invention will now be described. The second embodiment has the same structure as that of the first embodiment except that projections 50 to 53 and recesses 40 to 43 provided on each split surface 18 of sleeve halves 2a and 2b as well as projections 80 to 83 and recesses 70 to 73 provided on each split surface 58 of gland cover halves 5a and 5b have been modified to have another form of projection and recess, respectively. Between the embodiments, the same reference numeral will thus be assigned to the same structure, for which the overlapping description will not be repeated.

[0062]

Fig. 8 is an enlarged perspective view of the projection formed in the sleeve half of the mechanical seal according to the second embodiment.

[0063]

A projection 171 illustrated in Fig. 8 is the same as that in the first embodiment from a viewpoint that the projection is

formed by driving a drape pin 150 or the like into a hole formed by bringing two recesses 170 and 170 together, but is different from the first embodiment in that the drape pin is driven into a different direction. In the second embodiment, the drape pin 150 or the like is driven not in a shaft direction or a radial direction of a rotating shaft B but a direction between the shaft direction and the radial direction (an oblique direction). Therefore, the single drape pin 150 or the like would make the sleeve halves 2a and 2b less likely to be shifted in either the shaft direction or the radial direction. In this case, it is preferred that the drape pin 150 or the like be also driven into the oblique direction on the side symmetrical about the rotating shaft B. Moreover, it is preferred that the drape pin 150 or the like be driven into a different direction from the aforementioned drape pin 150 or the like. This is because the shift within the split surfaces 18 and 18 of the sleeve halves 2a and 2b can be prevented effectively by driving the drape pins 150 or the like into the mutually different directions. The clearance between the projection 171 formed of the drape pin 150 or the like and the matching recess 170 would be 10 μm or less, preferably 3 μm or less, or more preferably 0 μm . Each split surface 58 of the gland cover halves 5a and 5b including the projection 171 illustrated in Fig. 8 may also include a long and narrow projection instead in the same direction as that of the projections 80 to 83 described in the first embodiment.

[0064]

<Third embodiment>

A mechanical seal according to a third embodiment of the present invention will now be described. Similar to the second embodiment, the third embodiment has the same structure as that of the first embodiment except that a projection and a recess having a form different from that in the first embodiment are used. Between the embodiments, the same reference numeral will thus be assigned to the same structure, for which the overlapping description will not be repeated.

[0065]

Fig. 9 is an enlarged perspective view of the projection formed in a sleeve half of the mechanical seal according to the third embodiment.

[0066]

A split surface 18 of a sleeve half 2a includes a columnar projection 180, while a split surface 18 of a sleeve half 2b includes a recess (not shown) which is in the position opposing the projection 180 so as to be fitted therewith in close contact. The columnar projection 180 does not have an anisotropic form but has a function to prevent a shift on each split surface 18 of the sleeve halves 2a and 2b. The clearance between the projection 180 and the matching recess would be 10 μm or less, preferably 3 μm or less, or more preferably 0 μm . Each split surface 58 of gland cover halves 5a and 5b including the projection 180

illustrated in Fig. 9 may also include a long and narrow projection instead in the same direction as that of the projections 80 to 83 described in the first embodiment or the projection 171 described in the second embodiment, respectively.

[0067]

<Fourth embodiment>

A mechanical seal according to a fourth embodiment of the present invention will now be described. In the fourth embodiment, the structure same as that in the first embodiment will be assigned the same reference numeral as that in the first embodiment and described. A mechanical seal 1 according to the fourth embodiment includes at least: a rotary ring 3 which rotates while driven by a rotating shaft B of rotating equipment; a seal ring 4 which is brought into contact with the rotary ring 3 in a shaft direction of the rotating shaft B; and a gland cover 5 which is in a sealed state with the seal ring 4 to cover an outer side thereof. At least the rotary ring 3, the seal ring 4, and the gland cover 5 are split in the radial direction, where one surface of a split surface of at least the gland cover 5 includes projections 80 to 83 which are projected toward another surface of the split surface, while the other surface includes recesses 70 to 73 which are fitted to the projections 80 to 83. That is, unlike the mechanical seal 1 according to the first embodiment, the mechanical seal 1 according to the fourth embodiment is a so-called non-sleeve mechanical seal in which a sleeve 2 is not included. In this case,

it is preferred that a form excluding a sleeve portion and a flange portion closer to the atmosphere side relative to the sleeve portion, namely a flange portion including the O-ring 6 on the equipment side alone, be added to the structure of the mechanical seal 1, the sleeve portion corresponding to the portion of the sleeve 2 closer to the side of the rotating shaft B relative to the space 10. The flange part on the equipment side can be split in half but may not include projections 50 to 53 or recesses 40 to 43 on a split surface 18. Here, at least the gland cover 5 includes the projections 80 to 83 and the recesses 70 to 73.

Industrial Applicability

[0068]

The present invention can be applied to the shaft sealing for the rotating equipment or the like.

CLAIMS

1. A mechanical seal comprising at least:

a rotary ring which rotates while driven by a rotating shaft of rotating equipment;

a seal ring which is brought into contact with the rotary ring in a shaft direction of the rotating shaft; and

a gland cover which is in a sealed state with the seal ring to cover an outer side thereof,

wherein at least the rotary ring, the seal ring, and the gland cover are split into a respective radial direction, and

one surface of a split surface of at least the gland cover includes a projection which is projected toward another surface of the split surface, while the other surface includes a recess which is fitted to the projection.

2. The mechanical seal according to claim 1, further comprising a sleeve which rotates while driven by the rotating shaft and covers an outer side of the rotary ring while in a sealed state therewith,

wherein one surface of a split surface of the sleeve includes a projection which is projected toward another surface of the split surface, while the other surface includes a recess which is fitted to the projection.

3. The mechanical seal according to claim 1 or 2,
wherein the projection has an anisotropic form extending long in any direction within a plane of the split surface, and
the recess has an anisotropic form to be fitted to the anisotropic projection.

4. The mechanical seal according to any one of claims 1 to 3, comprising a plurality of the projections having the anisotropic form,

wherein the plurality of projections includes:

a first projection extending long along the shaft direction of the rotating shaft; and

a second projection extending long along the radial direction of the rotating shaft, and

the recess having the anisotropic form includes:

a first recess which is fitted to the first projection and extends long along the shaft direction of the rotating shaft; and

a second recess which is fitted to the second projection and extends long along the radial direction of the rotating shaft.

5. The mechanical seal according to any one of claims 1 to 4, wherein the split surfaces facing each other include two of the recesses, respectively, which extend long in the same

direction on the both split surfaces,

a pin which forms the projection is embedded in one of the two recesses, and

another recess of the two recesses is fitted to an exposed surface of the pin when the split surfaces are brought together.

6. The mechanical seal according to claim 5, wherein the pin is fixed such that more than half a volume of the pin is embedded in the one recess.

7. The mechanical seal according to any one of claims 1 to 6, comprising two pre-assemblies each including a rotary ring half, a seal ring half, and a gland cover half which are formed by splitting at least the rotary ring, the seal ring, and the gland cover, respectively, into the respective radial directions.

8. The mechanical seal according to any one of claims 1 to 7, comprising:

a coat layer formed of a fluorine-based resin on the one surface of the split surfaces; and

an elastic adhesive layer stacked on the coat layer on the other surface of the split surfaces,

wherein the elastic adhesive layer is interposed between the coat layers when the split surfaces are brought together.