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Inventor(s)	YAMAMOTO; Ryoma et al.

SLIDING COMPONENT

Abstract

A sliding component capable of stably maintaining its sliding surface in parallel to a sliding surface of the other sliding component is disposed at a relatively rotating position in a rotating machine and slides relatively on a counterpart sliding component. A sliding surface of the sliding component is provided with a fluid introduction groove configured to communicate with at least a side on which a fluid exists, and a dynamic pressure generation groove configured to communicate with the fluid introduction groove and extend in a circumferential direction, and the dynamic pressure generation groove is provided with uneven portions that repeatedly undulates toward its terminating end.

Inventors: **YAMAMOTO; Ryoma (Tokyo, JP), MURAKAMI; Yasuhiro (Tokyo, JP)**

Applicant: **EAGLE INDUSTRY CO., LTD.** (Tokyo, JP)

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Background/Summary

TECHNICAL FIELD
[0001] The present invention relates to a sliding component, for example, a sliding component that receives a load in a thrust direction.
BACKGROUND ART
[0002] In the field of a rotating machine, it is known that sliding components that receive loads in a thrust direction, such as thrust bearings, are used. Such sliding components rotate relative to each other while its sliding surface is in contact with the sliding surface of the other sliding component arranged to face its sliding surface in a rotation state of a rotary member. Accordingly, the rotation of the rotary member is maintained while supporting the thrust force.
[0003] In recent years, there has been a desire to reduce the energy lost due to sliding for environmental measures and the like. Therefore, some sliding components that receive loads in the thrust direction are configured to allow a fluid to be introduced between sliding surfaces to form a fluid film in order to improve lubricity and reduce friction.
[0004] For example, a sliding component illustrated in Patent Citation 1 includes a plurality of deep grooves which are formed in an annular shape and extend in a radial direction and a shallow groove which communicates with the deep groove and extends toward a downstream side in a relative rotation direction. The deep groove communicates with each of an inner diameter side and an outer diameter side of a sliding surface. The shallow groove is formed so that its depth becomes shallower as it goes from the upstream side toward the downstream side in the relative rotation direction. Further, the shallow groove is formed so that its radial width becomes narrower from the upstream side toward the downstream side in the rotation direction.
[0005] Accordingly, while the rotary member rotates, a fluid inside the shallow groove is subjected to a shearing force in accordance with the relative rotation of the sliding surfaces and flows toward a downstream side in the relative rotation direction. The shallow groove becomes shallower and narrower as it goes toward the peripheral edge. Therefore, a dynamic pressure is generated at the peripheral edge of the shallow groove so that the fluid can be smoothly supplied between the sliding surfaces. Further, the fluid inside the deep groove is introduced into the shallow groove. Accordingly, it is possible to stably form a fluid film between the sliding surfaces.
CITATION LIST
Patent Literature
[0006] Patent Citation 1: JP 2008-144864 A (Page 4, FIG. 1)
SUMMARY OF INVENTION
Technical Problem
[0007] In the sliding component of Patent Citation 1, since a plurality of terminating edges located on the downstream side in the relative rotation direction of the shallow groove as the dynamic pressure generation region are locally arranged in the circumferential direction of the sliding surface, the height difference of the dynamic pressure generated in the circumferential direction is large. Accordingly, when an external force is applied to the sliding component, the rotation shaft, and the like so that the positions of the pair of sliding components are slightly moved by the external force, the dynamic pressure generation region of the shallow groove moves. As a result, there is concern that the sliding surface of the other sliding component may be relatively inclined with respect to the sliding surface of the sliding component.
[0008] The present invention has been made in view of such problems and an object thereof is to provide a sliding component capable of stably maintaining its sliding surface in parallel to a sliding

surface of the other sliding component.

Solution to Problem

[0009] In order to solve the foregoing problem, a sliding component according to the present invention is a sliding component that is disposed at a relatively rotating position in a rotating machine and slides relatively on a counterpart sliding component, wherein a sliding surface of the sliding component is provided with a fluid introduction groove configured to communicate with at least a side on which a fluid exists, and a dynamic pressure generation groove configured to communicate with the fluid introduction groove and extend in a circumferential direction, and wherein the dynamic pressure generation groove is provided with an uneven portion that repeatedly undulates toward an terminating end of the dynamic pressure generation groove. According to the aforesaid feature of the present invention, the convex portion generates the dynamic pressure until the fluid introduced from the fluid introduction groove into the dynamic pressure generation groove moves toward the terminating end of the dynamic pressure generation groove. Accordingly, one dynamic pressure generation groove can generate the dynamic pressure at a plurality of positions in the circumferential direction. Therefore, the sliding component can stably maintain the sliding surface of the other sliding component in parallel to its sliding surface.

[0010] It may be preferable that the uneven portion has a corrugated shape. According to this preferable configuration, since the fluid is guided along the corrugated shape, the pressure loss caused by the uneven portion is decreased.

[0011] It may be preferable that a top portion of a convex portion of the uneven portion extends in a radial direction. According to this preferable configuration, the convex portion can generate a dynamic pressure substantially uniformly in the radial direction.

[0012] It may be preferable that a side wall of the dynamic pressure generation groove extends in a direction orthogonal to the sliding surface. According to this preferable configuration, the side wall can guide the fluid to the adjacent downstream convex portion. Therefore, the dynamic pressure generation groove not only has a high efficiency of generating the dynamic pressure, but also can smoothly guide the fluid to the terminating end of the dynamic pressure generation groove.

[0013] It may be preferable that a convex portion of the uneven portion extends to an opening edge of the dynamic pressure generation groove. According to this preferable configuration, the convex portion generates a high dynamic pressure.

[0014] It may be preferable that the fluid introduction groove is a deep groove and communicates with a concave portion of the uneven portion shallower than the deep groove. According to this preferable configuration, the fluid introduction groove can smoothly introduce the fluid into the concave portion. In addition, the convex portion continuous to this concave portion can smoothly generate a dynamic pressure.

[0015] It may be preferable that the terminating end of the dynamic pressure generation groove is formed by a slope of which a depth gradually becomes shallower toward a direction in which the dynamic pressure generation groove extends from the fluid introduction groove. According to this preferable configuration, the dynamic pressure generation groove can reliably generate a dynamic pressure at the convex portion and the terminating end of the dynamic pressure generation groove.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0016] FIG. **1** is a cross-sectional view schematically illustrating an example of a rotating device to which a sliding component according to a first embodiment of the present invention is applied.

[0017] FIG. **2** is a view of a sliding surface of the sliding component according to the first embodiment as viewed from an axial direction.

[0018] FIG. **3** is a cross-sectional view taken along a line A-A of FIG. **2**.

[0019] FIG. **4** is a view illustrating the sliding component at the time of stop using a cross-sectional view taken along a line B-B of FIG. **2**.
[0020] FIG. **5** is a view illustrating the sliding component at the time of relative rotation using a cross-sectional view taken along a line B-B of FIG. **2**.
[0021] FIG. **6** is an enlarged perspective view of a main part of the sliding surface of the sliding component according to the first embodiment.
[0022] FIG. **7** is a cross-sectional view illustrating a main part of a sliding component according to a second embodiment of the present invention.
[0023] FIG. **8** is a cross-sectional view illustrating a main part of a sliding component according to a third embodiment of the present invention.
[0024] FIG. **9** is a cross-sectional view illustrating a main part of a sliding component according to a fourth embodiment of the present invention.
[0025] FIG. **10** is a cross-sectional view illustrating a main part of a modification example of a sliding component according to the fourth embodiment of the present invention.
[0026] FIG. **11** is a view illustrating a main part of a sliding component according to a fifth embodiment of the present invention as viewed from an axial direction.
[0027] FIG. **12** is a view illustrating a main part of a modification example of a sliding component according to the fifth embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0028] Modes for carrying out a sliding component according to the present invention will be described below with reference to embodiments.

First Embodiment

[0029] A sliding component according to a first embodiment of the present invention will be described with reference to FIGS. **1** to **6**. Furthermore, in this embodiment, a pump will be described as an example of a rotating device to which the sliding component according to the first embodiment is applied.
[0030] As illustrated in FIG. **1**, a pump **1** pressure-feeds a fluid introduced into a housing **2** through an inflow path **2***a*, water in this embodiment, through an outflow path **2***b*. This pump **1** mainly includes the housing **2**, a rotation support shaft **3** which is a stationary member, an impeller **4** which is a rotary member, a motor **5**, a retaining member **10**, and a carbon bearing **30**.
[0031] The housing **2** has a shape that accommodates the rotation support shaft **3** and the impeller **4**. The housing **2** is provided with the inflow path **2***a* provided on the extension line of the rotation support shaft **3** and the outflow path **2***b* provided in a direction orthogonal to the inflow path **2***a*.
[0032] The rotation support shaft **3** is immovably fixed to a bottom portion of a bottomed cylindrical portion **20** of the housing **2**. Further, the retaining member **10** is externally fitted and fixed to the upper end of the rotation support shaft **3**.
[0033] The impeller **4** is provided with a shaft hole **4***a* which penetrates in the axial direction. The carbon bearing **30** which is a sliding bearing is internally fitted and fixed to the shaft hole **4***a*. The carbon bearing **30** is provided with a shaft hole **30***a* which penetrates in the axial direction and is formed in a cylindrical shape. The rotation support shaft **3** is inserted through the shaft hole **30***a* of the carbon bearing **30** and the impeller **4** is axially supported by the rotation support shaft **3** to be rotatable.
[0034] Further, a plurality of magnets **41** are fixed to a columnar base portion **40** of the impeller **4**.
[0035] The motor **5** is disposed outside the housing **2**. A bottomed cylindrical rotating body **50** which surrounds the cylindrical portion **20** of the housing **2** is connected to the motor **5**. A plurality of magnets **51** are fixed to the rotating body **50** and these magnets **51** are arranged to face the magnets **41**. Accordingly, the motor **5** is rotationally driven to rotate the impeller **4**.
[0036] When a force in the thrust direction is applied to the rotating impeller **4** as indicated by the black arrow in FIG. **1**, the carbon bearing **30** comes into contact with the retaining member **10** to prevent the impeller **4** from coming off from the rotation support shaft **3**. At this time, a thrust load

is applied from the carbon bearing **30** to the retaining member **10**.
[0037] Accordingly, a sliding surface **11** of the retaining member **10** and the sliding surface **31** of the carbon bearing **30** slide on each other. Due to this relative sliding, a fluid film is formed between the sliding surfaces **11** and **31**. Therefore, the sliding surfaces **11** and **31** smoothly slide on each other.
[0038] The retaining member **10** is a sliding component of the present invention. Further, the carbon bearing **30** is another sliding component of the present invention. First, the retaining member **10** will be described.
[0039] As illustrated in FIG. **2**, the retaining member **10** is formed in an annular shape. A D-shaped through-hole **10***a* is formed at the center of the retaining member **10**. This shape matches the end shape of the rotation support shaft **3**. Therefore, the rotation of the retaining member **10** relative to the rotation support shaft **3** is restricted.
[0040] Furthermore, the retaining member **10** is made of SiC, but the material is not limited thereto, and any sliding material that is used as a sliding component that receives a thrust load can be used.
[0041] The sliding surface **11** of the retaining member **10** includes a plurality of deep grooves **12** serving as fluid introduction grooves, a plurality of shallow grooves **13** serving as dynamic pressure generation grooves, and a land **14**. In the present specification, it will be described that the sliding surface **11** includes a portion which slides on the carbon bearing **30** and a portion which is a flat surface extending radially inward from this sliding portion. Furthermore, the entire portion of one end surface of the retaining member **10** may slide on the carbon bearing **30**.
[0042] The deep grooves **12** are arranged at three equal intervals. The shallow grooves **13** are arranged at three equal intervals. The land **14** is a portion other than the deep groove **12** and the shallow groove **13** in the sliding surface **11**. Further, the land **14** includes a flat surface **14***a* which is formed in the same plane. This flat surface **14***a* is a portion which substantially slides on the sliding surface **31** of the carbon bearing **30**. Hereinafter, the deep groove **12** and the shallow groove **13** will be described.
[0043] As illustrated in FIGS. **2** and **3**, the deep groove **12** extends in the radial direction. Further, the deep groove **12** communicates with at least a side on which a fluid exists. In this embodiment, the deep groove **12** communicates with the outer side and the inner side of the sliding surface **11**, respectively. Further, the deep groove **12** is formed into an inverted U-shape when viewed in the radial direction (see FIGS. **3** to **6**).
[0044] The shallow groove **13** extends in an arc shape along the circumferential direction of the sliding surface **11** from the radial center of the deep groove **12**, specifically, from the radially inner diameter side toward the downstream side in the relative rotation direction. Further, the shallow groove **13** includes a starting end **13***a* which communicates with the deep groove **12** and a closed terminating end **13***b*.
[0045] As illustrated in FIGS. **2** and **3**, the shallow groove **13** includes an outer diameter side wall **15**, an inner diameter side wall **16**, and a floor **17**.
[0046] As illustrated in FIG. **3**, the outer diameter side wall **15** extends to be substantially orthogonal to the flat surface **14***a* of the land **14**, in other words, in a direction orthogonal to the sliding surface **11**. The inner diameter side wall **16** extends to be substantially orthogonal to the flat surface **14***a* of the land **14** similarly to the outer diameter side wall **15**. Further, the inner diameter side wall **16** is disposed to face the outer diameter side wall **15** and extends substantially in parallel.
[0047] The floor **17** extends in the radial direction to be substantially orthogonal to the side walls **15** and **16**. Further, as illustrated in FIG. **4**, the floor **17** extends sinusoidally in the circumferential direction.
[0048] Specifically, the shallow groove **13** is provided with a plurality of convex portions **19**. In other words, the shallow groove **13** has a structure in which a plurality of concave portions **18** and a plurality of convex portions **19** are alternately arranged in the circumferential direction.

[0049] The concave portion **18** is a portion which is defined by the side walls **15** and **16** and the floor **17**. The depth D**1** to a deepest portion **18***a* of the concave portion **18** is shallower than the depth D**2** to a deepest portion **12***a* of the deep groove **12** (D**1**<D**2**). Furthermore, in FIG. **2**, the deepest portion **18***a* and a top portion **19***a* to be described later are indicated by thin lines.
[0050] Further, as illustrated in FIG. **4**, most of the concave portions **18** have an inverted U-shape when viewed in the radial direction with the deepest portion **18***a* as the bottom. These concave portions **18** are symmetrical with respect to a line (not illustrated) that passes through the deepest portion **18***a* and extends in the vertical direction of the paper, that is, the axial direction to be orthogonal to the sliding surface **11** and have substantially the same shape.
[0051] Further, the concave portion **18** located at the starting end **13***a* of the shallow groove **13** is formed only on the downstream side in the relative rotation direction with the deepest portion **18***a* as the bottom. In other words, the deepest portion **18***a* of the concave portion **18** located at the starting end **13***a* communicates with the deep groove **12**.
[0052] The convex portion **19** is a solid portion of which the outer surface is the floor **17**. The top portion **19***a* of the convex portion **19** is a so-called ridge line that extends linearly in the radial direction. Further, the top portion **19***a* extends to an opening edge **13***c* of the opening of the shallow groove **13**. In other words, the top portion **19***a* is formed at the same height as the flat surface **14***a* of the land **14**.
[0053] Further, most of the convex portions **19** have a U-shape when viewed in the radial direction with the top portion **19***a* as the top. These convex portions **19** are symmetrical with respect to a line (not illustrated) that passes through the top portion **19***a* and extends in the vertical direction of the paper, that is, the axial direction to be orthogonal to the sliding surface **11** and have substantially the same shape.
[0054] Further, the convex portion **19** located at the terminating end **13***b* of the shallow groove **13** is formed only on the upstream side in in the relative rotation direction with the top portion **19***a* as the top. In other words, the convex portion **19** located at the terminating end **13***b* is continuous to the land **14** located at the downstream side in the relative rotation direction.
[0055] Here, specifically, the floor **17** is formed by alternately arranging upstream slopes **17***a* and downstream slopes **17***b*. The upstream slope **17***a* extends from the deepest portion **18***a* of the concave portion **18** adjacent on the upstream side in the relative rotation direction to the top portion **19***a* of the reference convex portion **19** with one convex portion **19** as a reference. Similarly, the downstream slope **17***b* extends from the top portion **19***a* of the reference convex portion **19** to the deepest portion **18***a* of the concave portion **18** adjacent on the downstream side in the relative rotation direction.
[0056] Furthermore, the upstream slope **17***a* located at the terminating end **13***b* of the shallow groove **13** is referred to as a terminating end slope **17***c*.
[0057] Subsequently, the sliding surface **31** of the carbon bearing **30** is formed as a flat surface and this flat surface is not provided with a groove or the like. Further, the carbon bearing **30** is made of a material mainly composed of carbon.
[0058] Next, the function of the sliding surface **11** of the retaining member **10** will be described with reference to FIGS. **4** to **6**. Furthermore, FIGS. **4** and **5** illustrate a state in which the sliding surfaces **11** and **31** are separated from each other is illustrated in an exaggerated manner.
[0059] Further, in this description, the description will be made based on the deepest portion **18***a* and the top portion **19***a* with the top and bottom in FIGS. **4** and **5** reversed. Specifically, going from the deepest portion **18***a* toward the top portion **19***a* is expressed as going up.
[0060] Referring to FIG. **4**, the shallow groove **13** does not generate a dynamic pressure and the fluid inside the housing **2** flows into the deep groove **12** from the outer diameter side of the sliding surface **11** in the non-operation state when the impeller **4** is stopped. Further, the fluid is stored in the shallow groove **13**. At this time, since the concave portion **18** is minute, the fluid is likely to be stored therein due to surface tension.

[0061] When the impeller **4** starts rotating in the operation state, the fluid between the sliding surfaces **11** and **31** is mainly subjected to a shearing force in the circumferential direction, a dynamic pressure is generated in the shallow groove **13**, and the sliding surfaces **11** and **31** are slightly separated to become the state illustrated in FIG. **5**.
[0062] Hereinafter, this will be described in detail. The fluid which flows from the concave portion **18** located at the starting end **13***a* toward the downstream side generates a dynamic pressure while climbing over the upstream slope **17***a* located at the concave portion **18**, that is, climbing over the convex portion **19** located on the adjacent downstream side in the relative rotation direction as indicated by the arrow in FIG. **5**. Accordingly, the sliding surfaces **11** and **31** are separated from each other.
[0063] As described above, the top portion **19***a* of the convex portion **19** is linear. Therefore, the fluid climbing over the convex portion **19** immediately flows inside the concave portion **18** along the downstream slope **17***b* while being guided by the side walls **15** and **16** located at the concave portion **18** on the adjacent downstream side in the relative rotation direction. In this way, the shallow groove **13** can easily guide the fluid climbing over the convex portion **19** to the concave portion **18** on the adjacent downstream side of the convex portion **19**.
[0064] On the other hand, if the top portion of the convex portion has a planar shape with a width in the circumferential direction, that is, a configuration in which a land exists between the concave portions unlike this embodiment, the fluid is likely to be dispersed in the radial direction outside the adjacent concave portion when the fluid climbs over the same top portion. Such a configuration in which the land exists between the concave portions does not correspond to the dynamic pressure generation groove of the present invention in which the uneven portion that repeatedly undulates is provided.
[0065] Returning to the description of this embodiment, the fluid introduced into the shallow groove **13** flows toward the terminating end **13***b* while sequentially passing through the concave portion **18** and the convex portion **19** from the starting end **13***a* in the shallow groove **13**. Further, the fluid having reached the terminating end **13***b* climbs over the terminating end slope **17***c* located at the terminating end **13***b* and climbs onto the land **14**. That is, each convex portion **19** and the terminating end **13***b* of the shallow groove **13** can reliably generate a dynamic pressure that relatively separates the sliding surface **31** of the carbon bearing **30**.
[0066] Here, since the deep groove **12** communicates with the shallow groove **13**, the fluid can be easily supplied from the deep groove **12** to the shallow groove **13** when the fluid receives a shearing force toward the downstream side in the circumferential direction. Further, in this embodiment, as illustrated in FIGS. **5** and **6**, the deep groove communicates with the concave portion **18** located at the starting end **13***a* of the shallow groove **13**. Accordingly, the fluid can be smoothly introduced from the deep groove **12** to the concave portion **18** located at the starting end **13***a*.
[0067] As described above, the retaining member **10** of this embodiment generates a dynamic pressure in each convex portion **19** until the fluid introduced from the deep groove **12** into the shallow groove **13** moves toward the terminating end **13***b* of the shallow groove **13**. Accordingly, one shallow groove **13** can generate the dynamic pressure at a plurality of positions in the circumferential direction. Therefore, the retaining member **10** can stably maintain the sliding surface **31** of the carbon bearing **30** to be separated substantially in parallel to its sliding surface **11**.
[0068] Further, the concave portion **18** and the convex portion **19** of the shallow groove **13** have a corrugated shape due to the floor **17** in the shallow groove **13** formed in a sinusoidal shape. Therefore, the fluid flowing in the shallow groove **13** is guided along the corrugated floor **17**. Accordingly, the fluid flowing in the shallow groove **13** is less prone to turbulence due to sudden height differences and the like. For this reason, the pressure loss caused by the concave portion **18** and the convex portion **19** is small.
[0069] Further, the top portion **19***a* of the convex portion **19** extends in the radial direction as

described above. Therefore, the convex portion **19** can generate a dynamic pressure substantially uniformly in the radial direction.

[0070] Further, as described above, the side walls **15** and **16** of the shallow groove **13** can guide the fluid to the adjacent downstream convex portion **19**. Therefore, the shallow groove **13** not only has a high efficiency of generating the dynamic pressure, but also can smoothly guide the fluid to the terminating end **13***b* of the shallow groove **13**.

[0071] Further, in the shallow groove **13**, the dynamic pressure that is increased when climbing over the convex portion **19** also becomes difficult to escape to the outside of the shallow groove **13**.

[0072] On the other hand, in the configuration in which the land exists between the concave portions unlike this embodiment, the dynamic pressure that is increased when climbing over the convex portion is likely to escape to the outside of the near concave portion. Therefore, it is conceivable that a sufficient dynamic pressure cannot be obtained in the same concave portion. For this reason, the shallow groove **13** of this embodiment can efficiently generate the dynamic pressure in each convex portion **19** and the terminating end **13***b*.

[0073] Further, the top portion **19***a* of the convex portion **19** extends to the opening edge **13***c* of the shallow groove **13**. Therefore, the fluid climbing over the convex portion **19** is more efficiently sent out toward the sliding surface **31** of the carbon bearing **30** than the sliding surface **11** of the retaining member **10**.

[0074] On the other hand, when the top portion of the convex portion is further separated from the opening edge of the shallow groove toward the deepest portion (see FIGS. **9** and **10** as an example) unlike this embodiment, the amount of the fluid sent toward the sliding surface **31** of the carbon bearing **30** is reduced compared to the sliding surface of the retaining member. For this reason, the convex portion **19** of this embodiment can generate a high dynamic pressure.

[0075] Further, since the top portion **19***a* of the convex portion **19** extends to the opening edge **13***c* of the shallow groove **13**, the volume of the concave portion **18** sandwiched between the adjacent convex portions **19** is increased. Therefore, the amount of the fluid stored in the concave portion **18** increases. Accordingly, the shallow groove **13** can prevent poor lubrication from occurring even immediately after relative sliding between the sliding surfaces **11** and **31** starts.

[0076] Further, the fluid is smoothly and directly introduced from the deep groove **12** to the concave portion **18** located at the starting end **13***a*. Accordingly, the shallow groove **13** can reliably generate a dynamic pressure on the side of the starting end **13***a*. Therefore, the shallow groove **13** may efficiently introduce the fluid to the terminating end **13***b*.

[0077] Further, the top portion **19***a* of the convex portion **19** in the shallow groove **13** is continuous to the flat surface **14***a* of the land **14**. Therefore, the top portion **19***a* can function as a substantially sliding portion. Accordingly, the sliding surface **11** can disperse a surface pressure acting on itself.

[0078] Further, since the deep grooves **12** and the shallow grooves **13** are arranged at a plurality of equal intervals, the fluid is easily introduced to the terminating end **13***b* of each shallow groove **13**. On the other hand, in the configuration in which only one set of the deep groove and the shallow groove is formed and the shallow groove extends to the vicinity of the upstream side of the deep groove unlike this embodiment, the amount of the fluid introduced to the terminating end is likely to be reduced compared to the amount of the fluid introduced to the terminating end **13***b* of the shallow groove **13**. Therefore, it is possible to efficiently generate the dynamic pressure in each shallow groove **13** by arranging the plurality of deep grooves **12** and shallow grooves **13**.

[0079] Further, since the other concave portions **18** except for the most upstream concave portion **18** have the same shape and the convex portions **19** except for the most downstream convex portion **19** also have the same shape, the dynamic pressure generated at each convex portion **19** can be easily maintained approximately constant and furthermore, the dynamic pressure generation regions can be approximately equally distributed. Accordingly, the retaining member **10** can more stably maintain the sliding surface **31** of the carbon bearing **30** to be separated substantially in parallel to its sliding surface **11**.

[0080] Further, since the deepest portion **18***a* and the top portion **19***a* are linear, more convex portions **19** can be formed compared to a case in which the deepest portion and the top portion have a planar shape (see FIG. **9** as an example) unlike this embodiment. Accordingly, since it is possible to more densely arrange the dynamic pressure generation regions, the sliding surface **31** of the carbon bearing **30** can be more stably maintained to be separated substantially in parallel to its sliding surface **11**.
[0081] Further, the sliding component of the present invention is the retaining member **10**. The retaining member **10** is less likely to wear out than the carbon bearing **30**. Therefore, the retaining member **10** is suitable as a mating material for the carbon bearing **30**.
Second Embodiment
[0082] Next, a sliding component according to a second embodiment of the present invention will be described with reference to FIG. **7**. Furthermore, the description of the same configuration and overlapping configuration as in the first embodiment will be omitted.
[0083] A sliding surface **111** of a retaining member **110** of the second embodiment includes the deep groove **12**, a shallow groove **113**, and a land **114**. A floor **117** of the shallow groove **113** is formed in a corrugated shape in which an isosceles triangle (on the side of a deepest portion of a concave portion **118**) and an inverted isosceles triangle (on the side of a top portion of a convex portion **119**) are continuous.
[0084] Even in such a configuration, the concave portion **118** and the convex portion **119** of the shallow groove **113** are formed in a corrugated shape. Therefore, the fluid flowing in the shallow groove **113** is guided along the corrugated shape. For this reason, the pressure loss caused by the concave portion **118** and the convex portion **119** is decreased. That is, the shape of the uneven portion of the shallow groove may be changed as appropriate as long as the uneven portion has a line-symmetrical shape with respect to a line that passes through the top portion or the deepest portion and extends in the axial direction to be orthogonal to the sliding surface. Further, when one top portion is used as a reference, the deepest portion on the adjacent upstream side in the relative rotation direction and the deepest portion on the same adjacent downstream side are preferably connected in a linear shape or a curved shape.
Third Embodiment
[0085] Next, a sliding component according to a third embodiment of the present invention will be described with reference to FIG. **8**. Furthermore, the description of the same configuration and overlapping configuration as in the first embodiment will be omitted.
[0086] A sliding surface **211** of a retaining member **210** of the third embodiment includes a fluid introduction groove **212**, a dynamic pressure generation groove **213**, and a land **214**. The fluid introduction groove **212** is formed to have the same depth as the shallow groove **13** of the first embodiment. The dynamic pressure generation groove **213** is the same as the shallow groove **13** of the first embodiment. Even in such a configuration, the fluid can be guided to the dynamic pressure generation groove **213** through the fluid introduction groove **212**. That is, the fluid introduction groove may not be deeper than the dynamic pressure generation groove.
Fourth Embodiment
[0087] Next, a sliding component according to a fourth embodiment of the present invention will be described with reference to FIG. **9**. Furthermore, the description of the same configuration and overlapping configuration as in the first embodiment will be omitted.
[0088] A sliding surface **311** of a retaining member **310** of the fourth embodiment includes the deep groove **12**, a shallow groove **313**, and a land **314**. A floor **317** of the shallow groove **313** is formed in a corrugated shape in which an isosceles trapezoid (on the side of a deepest portion **318***a* of a concave portion **318**) and an inverted isosceles trapezoid (on the side of a top portion **319***a* of a convex portion **319**) are continuous. Accordingly, the top portion **319***a* of the convex portion **319** becomes a flat surface. On the other hand, the top portion **319***a* is further separated from an opening edge **313***c* of the shallow groove **313** toward the deepest portion **318***a* of the concave

portion **318**.

[0089] Accordingly, when the fluid flowing in the shallow groove **313** rides on the top portion **319***a* of the convex portion **319**, the fluid is guided to the downstream concave portion **318** by the side wall of the shallow groove **313**. In this way, when the fluid can smoothly move from the concave portion to the next concave portion, the shape of the top portion of the convex portion and the axial dimension of the sliding surface may be changed as appropriate.

[0090] Furthermore, as in a sliding surface **311**A of a retaining component **310**A illustrated in FIG. **10**, a floor **317**A of the shallow groove **313**A may be formed in a sinusoidal shape as in the first embodiment and a top portion **319***a*A of a convex portion **319**A may be separated from an opening edge **313***c* toward a deepest portion **318***a*A of the concave portion **318**A. In such a configuration, it is possible to improve the efficiency of introducing the fluid toward the terminating end compared to the first embodiment.

Fifth Embodiment

[0091] Next, a sliding component according to a fifth embodiment of the present invention will be described with reference to FIGS. **11** and **12**. Furthermore, the description of the same configuration and overlapping configuration as in the first embodiment will be omitted.

[0092] A sliding surface **411** of a retaining member **410** of the fifth embodiment includes the deep groove **12**, a shallow groove **413**, and a land **414**. A top portion **419***a* of a convex portion **419** of the shallow groove **413** has a curved shape that protrudes toward a terminating end **413***b* of the shallow groove **413** as it goes toward the center in the radial direction. In such a configuration, since the convex portion **419** can easily guide the fluid toward the center in the radial direction of the shallow groove **413**, it is possible to more reliably guide the fluid toward the downstream adjacent concave portion. Furthermore, the concave portion and the deepest portion thereof are not illustrated in FIG. **11**.

[0093] Furthermore, as in a retaining component **510** illustrated in FIG. **12**, a top portion **519***a* of a convex portion **519** of a shallow groove **513** may have a trapezoidal shape that protrudes toward a terminating end **513***b* of the shallow groove **513**. Furthermore, the concave portion and the deepest portion thereof are not illustrated in FIG. **12**.

[0094] In this way, the shape of the top portion of the convex portion may be changed as appropriate if the top portion spans each side wall of the shallow groove. Further, the bottom may extend at an angle in the radial direction or may extend in a curved manner in the radial direction. These also apply to the deepest portion of the concave portion.

[0095] Although the embodiments of the present invention have been described above with reference to the drawings, the specific configuration is not limited to these embodiments, and any changes or additions that do not depart from the gist of the present invention are included in the present invention.

[0096] For example, in the first to fifth embodiments, although it has been described that the mating material of the carbon bearing is the sliding component, the present invention is not limited thereto and the mating material may be a sliding bearing or one sliding component constituting a thrust bearing. Further, the pair of sliding components including the sliding surfaces of the embodiment may be arranged to face each other. Further, from the viewpoint of maintaining the shape of the convex portion in the shallow groove for a long time, it is preferable to provide the shallow groove in a sliding component that is less likely to change over time due to wear or the like, for example, a hard sliding component.

[0097] Further, in the first to fifth embodiments, although it has been described that the dynamic pressure generation groove extends only to the downstream side of the circumferential direction, the present invention is not limited thereto and the dynamic pressure generation groove may also extend to the upstream side of the circumferential direction. In such a configuration, a fluid film can also be formed during reverse rotation.

[0098] Further, in the first to fifth embodiments, although it has been described that the dynamic pressure generation groove extends in the circumferential direction of the sliding surface, the present invention is not limited thereto. If the dynamic pressure generation groove extends in the circumferential direction, the dynamic pressure generation groove may be inclined in the radial direction or a part thereof may be bent in the radial direction. If at least the circumferential component is provided, the shape may be changed as appropriate.

[0099] Further, in the first to fifth embodiments, although it has been described that the dynamic pressure generation groove is provided along the same circular shape, the present invention is not limited thereto and the dynamic pressure generation groove may be provided at different phases in the radial direction.

[0100] Further, in the first to fifth embodiments, although it has been described that the plurality of fluid introduction grooves and dynamic pressure generation grooves are provided, the present invention is not limited thereto and only one of each may be formed. Even in such a configuration, it is possible to generate a dynamic pressure at a plurality of positions of one shallow groove.

[0101] Further, in the first to fifth embodiments, although it has been described that the fluid inside the housing flows into the fluid introduction groove from the outer diameter side of the sliding surface, the present invention is not limited thereto and the fluid inside the housing may flow thereinto from the inner diameter side of the sliding surface. For this reason, although it has been described that the fluid introduction groove communicates with each of the outside and the inside of the sliding surface, the present invention is not limited thereto and the fluid introduction groove may communicate with only one side of the outer diameter side and the inner diameter side.

[0102] Similarly, when the sliding surface of the sliding component and the sliding surface of the other sliding component overlap each other, for example, when the sliding surface of the sliding component has a larger diameter than the sliding surface of the other sliding component, a portion located on the outer diameter side of the sliding surface of the other sliding component in the fluid introduction groove opens in the axial direction and hence the fluid may be introduced from the opening portion. For this reason, the fluid introduction groove may not communicate with each of the outer diameter side and the inner diameter side of the sliding surface if the fluid introduction groove opens to introduce the fluid inside the housing.

[0103] Further, in the first to fifth embodiments, although it has been described that the top portion as the apex is disposed at the lower position, the present invention is not limited thereto and the top portion as the apex may be located at the upper position by reversing the top and bottom in FIGS. **4** and **5**.

[0104] Further, in the first to fifth embodiments, although it has been described that the convex portion has a line-symmetrical shape with respect to a line that passes through the top portion and extends in the axial direction to be orthogonal to the sliding surface, the present invention is not limited thereto and the convex portion may not have a line-symmetrical shape. Further, the convex portion may be inclined toward the upstream side or the downstream side.

[0105] Further, in the first to fifth embodiments, although it has been described that the plurality of convex portions are provided inside the dynamic pressure generation groove, the present invention is not limited thereto and only one convex portion may be provided.

[0106] Further, in the first to fifth embodiments, although it has been described that the plurality of concave portions have the same shape, the present invention is not limited thereto. For example, the volume of the concave portion may increase or decrease as it goes toward the downstream side and the concave portion may have different shapes. This also applies to the convex portions.

REFERENCE SIGNS LIST

[0107] **3** Rotation support shaft (stationary member) [0108] **4** Impeller (rotary member) [0109] **10** Retaining member (sliding component) [0110] **11** Sliding surface [0111] **12** Deep groove (fluid introduction groove) [0112] **13** Shallow groove (dynamic pressure generation groove) [0113] **13***a* Starting end [0114] **13***b* Terminating end [0115] **13***c* Opening edge [0116] **15**, **16** Side wall [0117] **17***c* Terminating end slope (slope of which depth gradually becomes shallower) [0118] **18** Concave portion [0119] **19** Convex portion [0120] **19***a* Top portion [0121] **30** Carbon bearing (counterpart sliding component) [0122] **31** Sliding surface [0123] **110** to **510** Retaining member (sliding component) [0124] **111** to **411** Sliding surface [0125] **113**, **313** to **513** Shallow groove (dynamic pressure generation groove) [0126] **118**, **318**, **318**A Concave portion [0127] **119**, **319** to **519** Convex portion [0128] **212** Fluid introduction groove [0129] **213** Dynamic pressure generation groove [0130] **313***c* Opening edge [0131] **319***a* to **519***a* Top portion [0132] **413***b*, **513***b* Terminating end [0133] D**1** Depth [0134] D**2** Depth

Claims

1. A sliding component that is disposed at a relatively rotating position in a rotating machine and slides relatively on a counterpart sliding component, wherein a sliding surface of the sliding component is provided with a fluid introduction groove configured to communicate with at least a side on which a fluid exists, and a dynamic pressure generation groove configured to communicate with the fluid introduction groove and extend in a circumferential direction, and wherein the dynamic pressure generation groove is provided with an uneven portion that repeatedly undulates toward an terminating end of the dynamic pressure generation groove.
2. The sliding component according to claim 1, wherein the uneven portion has a corrugated shape.
3. The sliding component according to claim 1, wherein a top portion of a convex portion of the uneven portion extends in a radial direction.
4. The sliding component according to claim 1, wherein a side wall of the dynamic pressure generation groove extends in a direction orthogonal to the sliding surface.
5. The sliding component according to claim 1, wherein a convex portion of the uneven portion extends to an opening edge of the dynamic pressure generation groove.
6. The sliding component according to claim 1, wherein the fluid introduction groove is a deep groove and communicates with a concave portion of the uneven portion shallower than the deep groove.
7. The sliding component according to claim 1, wherein the terminating end of the dynamic pressure generation groove is formed by a slope of which a depth gradually becomes shallower toward a direction in which the dynamic pressure generation groove extends from the fluid introduction groove.
8. The sliding component according to claim 2, wherein the terminating end of the dynamic pressure generation groove is formed by a slope of which a depth gradually becomes shallower toward a direction in which the dynamic pressure generation groove extends from the fluid introduction groove.
9. The sliding component according to claim 3, wherein the terminating end of the dynamic pressure generation groove is formed by a slope of which a depth gradually becomes shallower toward a direction in which the dynamic pressure generation groove extends from the fluid introduction groove.
10. The sliding component according to claim 4, wherein the terminating end of the dynamic pressure generation groove is formed by a slope of which a depth gradually becomes shallower toward a direction in which the dynamic pressure generation groove extends from the fluid introduction groove.
11. The sliding component according to claim 5, wherein the terminating end of the dynamic pressure generation groove is formed by a slope of which a depth gradually becomes shallower toward a direction in which the dynamic pressure generation groove extends from the fluid introduction groove.
12. The sliding component according to claim 6, wherein the terminating end of the dynamic pressure generation groove is formed by a slope of which a depth gradually becomes shallower

toward a direction in which the dynamic pressure generation groove extends from the fluid introduction groove.