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(54) **Levelling for offshore structures**

Ausrichten von Offshore-Strukturen

Nivellement pour structures en mer

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Description

[0001] The present invention relates to a method of and apparatus for adjustment of the level of an interface between an offshore foundation and a structure to be supported thereby, see e.g. the support strutures disclosed in GB2129472A. In preferred embodiments the structure is a tower type structure, for example a tower for a wind turbine.

[0002] It is generally desirable that a tower, platform or other structure is precisely vertically aligned, especially for tall structures, and for this reason it is important that the interface at which the tower, platform or other structure connects to its foundation is substantially horizontal, within a required tolerance. However, an offshore foundation may not provide such an interface since in many cases it is not possible to guarantee a level foundation due to the method of construction or installation of the offshore foundation.

[0003] Exemplary level-critical applications include offshore assemblies such as wind turbines, weather stations, lighthouses, platforms for the oil and gas industry and so on.

[0004] Typically, offshore assemblies comprise an offshore foundation and a structure (for example, a tower or platform) mounted thereto. The height of the offshore foundation will be such that the tower, platform or other structure remains above sea level after installation of the lower parts of the offshore foundation. The most common installation techniques first install the offshore foundation on the sea-bed without the upper parts. The tower, platform or other structure is then mounted on top of the offshore foundation.

[0005] It is desirable that the tower, platform or other structure is precisely vertically aligned, and for this reason it is important that the interface at which the tower, platform or other structure connects to the offshore foundation is horizontal.

[0006] Known offshore foundations for offshore structures are predominantly monopiles, gravity foundations and piled jackets

[0007] The basic structure of a monopile is a tube, usually made of steel. The monopile is hammered or drilled into the sea-bed, and extends upwardly to project above sea level. Connection between the monopile and the structure above (e.g. the tower of a wind turbine) is provided by a transition piece.

[0008] The monopile transition piece is a tube that typically has a slightly larger diameter than the monopile so that it can be mounted over the monopile. The transition piece comprises a flange to connect the monopile to the tower with nuts and bolts.

[0009] It is desirable that the offshore foundation is level (i.e. horizontal), typically to within a normal margin of 0.5° tilt, but this is difficult to achieve whilst drilling or hammering the monopile into the soil. Therefore an additional function of the transition piece is to level the interface to the tower.

[0010] Gravity foundations are used for many types of offshore assembly when the location and the type of the structure make it feasible or advantageous to support the structure on the sea-bed. A gravity foundation holds the structure in place using the weight of the gravity foundation, and so drilling or hammering into the sea-bed is not necessary. However, prior to installation of the gravity foundation, the sea-bed beneath has often been prepared by dredging, to provide a flat and level surface by infilling the dredged area with gravel and concrete. However, where the gravity foundation is placed directly on the seabed, some correction for verticality may need to be included at the offshore foundation-to-structure interface to satisfy the functional requirements of the structure.

[0011] Connection of the structure to the gravity foundation is typically by way of a flange which is embedded in the gravity foundation, or by an anchor bolt cage, where several long bolts are embedded in the gravity foundation.

[0012] Where an anchor bolt cage is provided, it is common to use shims placed at each bolt to provide a horizontal surface. However, further problems can arise from this approach. The bolt ends are required to project a certain distance through the interface in order to fasten the bolts. In some situations, the top surface of the gravity foundation can be so uneven that the bolts on the lower parts are too short and do not project sufficiently far above the interface. In order to overcome this problem, the concrete surrounding the affected parts can be removed. However, such a procedure is labour- and time- intensive.

[0013] There is a need for an alternative and improved means of adjusting the level of an interface between an offshore foundation and a structure mounted thereto.

[0014] Viewed from a first aspect the present invention provides an apparatus for adjusting the level of an interface between an offshore foundation and a structure to be mounted thereto, wherein the apparatus comprises: two shims, each rotatable about a rotational axis with respect to the other and to the offshore foundation, wherein the shims are for positioning one on top of the other between the offshore foundation and the structure, and wherein each shim has a width generally transverse to the rotational axis and a depth generally in the direction of the rotational axis, and the depth of the shim varies generally linearly across the width of the shim.

[0015] As a result of the features of the present invention, precise fine adjustment of the level of the offshore foundation is facilitated by rotational adjustment of one or both of the two shims. Furthermore, it is easy and quick to install the shims.

[0016] The structure may be a tower type structure, such as a tower for a wind turbine.

[0017] In general, the rotational axis of the shims, in use, should be such that it allows for correction of the offshore foundation surface to horizontal. The rotational axis may for example be generally coaxial with a central

axis of the offshore foundation or the structure, which would be the vertical axis of the offshore foundation for a perfect installation.

[0018] Preferably, the shims are circular, and more preferably have an annular, or ring-like, configuration such that each shim has an inner and an outer diameter. In a typical preferred embodiment the shims would be circular rings in order that they can rotate relatively to one another and remain aligned, although it is not essential that the shims are circles. For example they may be slightly oval in plan view. Design and installation considerations place limitations on the preferred inner and outer diameter (though these are not related to the levelling functionality of the shims). For ease of installation, it is preferred that the outer diameters of the shims do not project outwardly of the outer periphery of the portion of the offshore foundation to which they are attached. It is also advantageous to maintain communication between the interiors of the offshore foundation and structure mounted thereto, which may be hollow. In one exemplary embodiment, the offshore structure may be a wind turbine, which may be mounted atop an offshore foundation. Utilities such as power cables run from the turbine at the top of the wind turbine tower, through the tower interior, through the offshore foundation and along the sea-bed. Therefore, the inner diameter is such to maintain the communication between the interior of the offshore foundation and tower, to facilitate the provision of utilities between the interiors. Typically the shim may be sized so that it fits between the offshore foundation and the structure without protruding to any great extent.

[0019] As a result of the fact that the depth of the shim varies generally linearly across the width of the shim, the shims each have a maximum depth and a minimum depth located at opposing ends of the width of the shim, i.e. diametrically opposite. The difference between the maximum and minimum depths is denoted Δ. The width (or diameter) D and quantity Δ define a shim angle θ, such that: $\theta = \tan^{-1}(\Delta/D)$. The shim angle θ is the angle of intersection of planes aligned with upper and lower surfaces of the shim. It will be understood that the upper and lower surfaces do not need to be perfectly flat, but preferably they are generally flat and sufficiently planar to allow the two shims to interact with each other and with other structural elements of the offshore foundation and the structure in order to perform their levelling function. In a preferred embodiment, the shim angles θ of each shim are identical. This allows for the correction to the level to be varied from no correction at all, when the maximum depth of one shim is aligned with the minimum depth of the other shim, to a maximum correction of 2θ when the maximum depths of both shims are aligned.

[0020] The shim angle θ of each shim is not particularly limited. In some embodiments, the shim angle of each shim may be less than 20°, preferably less than 10° and more preferably less that 5°. Where structural tolerances are more stringent, the shim angle θ of each shim may be less than 1°, for example between 0.25° and 0.75°, and most advantageously is 0.5°. When the shim angle θ is 0.5°, the angle of tilt that can be corrected for with two shims is between 0 and 1°. Any greater angle of deviation from the horizontal may not be acceptable in the installation of an offshore structure foundation, so larger shim angles may not be necessary in this particular application.

[0021] Each shim may comprise holes spaced evenly around a circumference of the shim for receiving connectors (for example, bolts) to connect the structure to the offshore foundation.

[0022] As mentioned above, the shim preferably has a circular or annular configuration. A circular/annular configuration is most practical for ease of rotation of each shim with respect to the other and/or the offshore foundation. However, other configurations are possible, provided that they provide the same levelling functionality. Another example of a possible shape is a multi-sided shape, preferably with one side per hole, such that the shim is rotationally symmetric (from a plan view), with a number of lines of rotational symmetry corresponding to the number of holes.

[0023] In preferred embodiments, the apparatus comprises a fixing ring for connection to the offshore foundation, for example a steel channel ring. The preferred fixing ring comprises a lower flange and upper flange. The lower flange is for connection to the offshore foundation, whereas the upper flange is for mounting the shims thereto. The lower flange may have a number of holes therein suitable for mounting the flange to the offshore foundation, for example via a bolt cage cast into a concrete gravity foundation or by connection to the transition piece of a monopile. The upper flange of this preferred embodiment has a number of holes equal to the number of holes in the shims, circumferentially spaced apart identically to the spacing between the holes in the shims. In use, the fixing ring is mounted to the offshore foundation, a lower shim is mounted to the fixing ring and an upper shim is placed atop the lower shim. The structure is then mounted atop the upper shim, the upper surface of which is horizontal. Optionally, a circular groove is cut in both sides of the lower shim, the lower side of the upper shim and the upper side of the fixing ring. The groove is preferably positioned away from the bolt holes so that the structural integrity of the shims and fixing ring is maintained. When the fixing ring and shims are placed atop the offshore foundation, the groove in the lower side of the lower shim is aligned with the groove in the upper side of the fixing ring, and the groove in the upper side of the lower shim is aligned with the groove in the lower side of the upper shim. Thus, a pair of annular cavities is formed. Each of the annular cavities may be provided with a friction reducing system, for example, ball bearings. Provision of a friction reducing system in each annular cavity allows the lower shim to be freely rotated relative to the fixing ring, and the upper shim to be freely rotated with respect to the lower shim.

[0024] In some embodiments, each of the annular cav-

ities also receives a sealing barrier, for example an o-ring, to prevent the ingress of water into the interior of the assembly through the interfaces between the offshore foundation, the shims, and the structure.

[0025] In other embodiments, a second groove is cut, concentric with, and preferably radially outward of, the first groove, in both sides of the lower shim, the lower side of the upper shim and the upper side of the fixing ring. Thus, the annular cavities defined above may form a first pair of annular cavities and an additional second pair of annular cavities can be formed concentric with the first pair of annular cavities. In such embodiments, the second pair of annular cavities is provided with the sealing barrier, and the first pair of annular cavities does not require a sealing barrier.

[0026] The shims may be used with a gravity foundation, a monopile, or any other suitable offshore foundation.

[0027] The invention also extends to an offshore structural assembly, offshore foundation and/or offshore assembly comprising the apparatus according to the first aspect of the present invention, and optionally any of the preferable features of the first aspect.

[0028] According to a second aspect of the present invention, there is provided a method of levelling an offshore structural assembly comprising using the apparatus according to the first aspect of the present invention, and any of the preferable features of the first aspect. The offshore structural assembly may be an offshore assembly comprising an offshore foundation and a structure mounted thereto.

[0029] According to a third aspect of the present invention, there is provided a method of adjusting the level of an interface between an offshore foundation and a structure to be mounted thereto, the method comprising: mounting two shims one on top of the other atop the offshore foundation; and rotating at least one shim to correct an angle of tilt of the offshore foundation and to hence provide a generally horizontal plane for mounting the structure on the offshore foundation; wherein each shim has a width generally transverse to the rotational axis and a depth generally in the direction parallel to the rotational axis, and the depth of the shim varies generally linearly across the width of the shim.

[0030] The structure may be a tower type structure, such as a tower for a wind turbine.

[0031] In preferred embodiments, the method comprises attaching a fixing ring, such as a steel channel ring, to the offshore foundation, said fixing ring preferably comprising an upper and lower flange, with the shims then being placed on top of the fixing ring. Preferably, the method further comprises: placing a lower shim atop the upper flange of the fixing ring; rotating the lower shim; placing an upper shim atop the lower shim; rotating the upper shim; placing a tower atop the shims, said tower comprising a lower flange; and placing bolts through holes provided in the lower flange of the tower, the shims and the upper flange of the fixing ring.

[0032] A preferred embodiment will now be described by way of example only and with reference to the following drawings in which:

Figure 1 shows a perspective view of two shims rotatable with respect to one another;
Figure 2 shows two shims atop a steel channel ring; and
Figure 3 shows two shims in an installed position on an offshore foundation.

[0033] An exemplary pair of shims 1, 1' is shown in Figure 1. Each has an annular shape with an outer diameter (D) of 5500 mm and an inner diameter (d) of 4920 mm. The maximum depth is 68 mm, and the minimum depth is 20 mm. Of course, these dimensions will depend upon the particular application of use, and may vary considerably.

[0034] The shims 1,1' are made of an appropriate steel, for example grade NV DW36 355. Each face is machined to high-precision. The assumed machine tolerances are 1.5 mm maximum level difference between any two points on the machined annular surface.

[0035] The shim angle θ of each shim is 0.5°. Thus by using two shims 1, 1', the range of angles that can be corrected for is between 0 and 1°. The maximum correction is achieved when the maximum depths of the two shims are circumferentially aligned (from which it of course follows that the minimum depths are also aligned). The minimum correction (i.e. no correction) is obtained by aligning the maximum depth of one shim with the minimum depth of the other shim.

[0036] For some applications, greater deviations from horizontal of greater than 1° are not to be expected, since this would mean tolerances had been exceeded in the installation of the offshore foundation.

[0037] In the particular embodiment shown in the Figures, holes 2 with a diameter of 54 mm are evenly spaced around the shim. Each shim comprises 128 holes. Of course, these details will depend on the particular application (for example, the type of wind turbine or other structure to be mounted to the offshore foundation).

[0038] Figure 2 shows the two shims 1, 1' resting on top of a steel channel ring 3 (fixing ring). The steel channel ring comprises an upper flange 4 and a lower flange 5. The lower flange comprises holes appropriately sized and spaced to receive bolts from a bolt cage provided in the offshore foundation 6. The steel channel ring 3 is thereby secured to the offshore foundation 6 (as shown in Figure 3).

[0039] A groove 10 mm wide by 5 mm deep is cut in both sides of the lower shim 1', the lower side of the upper shim 1 and the upper side of the upper flange 4 of steel channel ring 3. This groove is positioned away from the bolt holes, i.e. radially outward or radially inward of the location of the holes.

[0040] When the fixing ring 3 and shims 1, 1' are placed atop the offshore foundation 6, the groove in the lower

side of the lower shim 1' is aligned with the groove in the upper side of the upper flange 4 of the steel channel ring 3, and the groove in the upper side of the lower shim 1' is aligned with the groove in the lower side of the upper shim 1. Thus a first pair of annular cavities is formed. This first pair of annular cavities acts as a bearing race, and receives ball bearings. This reduces friction and allows the lower shim 1' to be freely rotated relative to the steel channel ring 3, and the upper shim 1 to be freely rotated with respect to the lower shim 1'.

[0041] In some embodiments, the first pair of annular cavities also each receive a sealing barrier, for example an o-ring, to prevent the ingress of water into the interior of the assembly through the interfaces between the offshore foundation, the shims, and the structure.

[0042] In other embodiments, a second groove is cut, concentric with, and preferably radially outward of, the first groove, in both sides of the lower shim 1', the lower side of the upper shim 1' and the upper side of upper flange 4 of the steel channel ring 3. A second pair of annular cavities is hence formed by the second grooves, in addition to and concentric with the first pair of annular cavities. In this case the second pair of annular cavities is provided with the sealing barrier, and the first annular cavities do not include a sealing barrier.

[0043] To correct the angle of tilt of the offshore foundation, the lower shim 1' is placed atop the steel channel ring 3 and is rotated appropriately. In the installed position, the holes 2 in the lower shim 1' should be aligned with the holes in the upper flange 4 of the steel channel ring 3. The upper shim 1 is then placed on top of the lower shim 1' and is also rotated. The holes 2 in the upper shim 1 should align with the holes 2 in the lower shim 1' in an installed position. The upper surface of the upper shim 1 should be horizontal in the installed position. The final tolerance on horizontal will be the finest adjustment that can be made by rotation of the shims or a single shim. This is hence the total angle that can be corrected by one shim divided by half the number of holes in the shim, since the number of holes defines the minimum rotational adjustment that can be made. In the example described herein the tolerance would be +/-0.5°/64 = +/-0.008°.

[0044] Once the shims have provided a horizontal surface, within the tolerance set out above, the tower 7 can be mounted on top. This is shown in Figure 3. The lower flange 8 of the tower has holes corresponding to the aligned holes in the shims and steel channel ring 3. Bolts 9 are passed through each of the holes to secure the tower to the horizontal surface.

[0045] The preferred embodiment above has been described with reference to an offshore structure in the form of a wind turbine. It will however be appreciated that the levelling system described herein could equally well be applied to other offshore structures where it is desired to provide levelling between an offshore foundation and a structure to be mounted thereon. The invention thus extends to any type of offshore structure where levelling is required.

Claims

1. An apparatus for adjusting the level of an interface between an offshore foundation (6) and a structure (7) to be mounted thereto, wherein the apparatus comprises:

   two shims (1, 1'), each rotatable about a rotational axis with respect to the other and to the offshore foundation,
   a fixing ring (3) for mounting the shims (1, 1') to the offshore foundation (6),
   wherein the shims are for positioning one on top of the other between the offshore foundation (6) and the structure (7),
   wherein each shim has a width generally transverse to the rotational axis and a depth generally in the direction of the rotational axis, and the depth of the shim varies generally linearly across the width of the shim; and
   wherein a first shim (1') for mounting to the fixing ring (3) comprises a first circular groove provided in each of opposing first and second faces of the first shim (1'), said first surface for contacting the fixing ring (3) and said second surface for contacting a second shim (1), and wherein the second shim is provided with a corresponding first groove in a first face for contacting the first shim (1').

2. An apparatus as claimed in claim 1, wherein a shim angle θ of each shim (1,1'), which is the angle θ of intersection of planes aligned with upper and lower surfaces of the shim, is less than 1°, preferably wherein the shim angle is about 0.5°.

3. An apparatus as claimed in claim 1 or 2, wherein a shim angle θ of each of the shims, which is the angle θ of intersection of planes aligned with upper and lower surfaces of the shim, is identical.

4. An apparatus as claimed in any preceding claim, wherein the shims are circular, and preferably are annular.

5. An apparatus as claimed in any preceding claim, wherein each shim comprises holes (2) spaced evenly around a circumference of the shim for receiving connectors for retaining the shims in an installed position.

6. An apparatus as claimed in any preceding claim, wherein the fixing ring comprises a flange (5) for mounting to the offshore foundation and a flange (4) for supporting the shims.

7. An apparatus as claimed in claim 6, wherein the fixing ring (3) comprises a circular groove in the flange surface (4) for contact with the first shim (1').

8. An apparatus as claimed in claim 7, wherein the groove in the first surface of the first shim (1') is aligned with the groove in the flange surface (4) of the fixing ring (3), and wherein the groove in the first face of the second shim (1) is aligned with the groove in the second face of the first shim (1'), a pair of annular cavities being formed thereby in an installed position.

9. An apparatus as claimed in claim 8, wherein a friction reducing system is provided in each annular cavity.

10. An apparatus as claimed in claim 9, wherein the annular cavity is provided with a sealing barrier;
or wherein a further pair of annular cavities are provided by providing second grooves in each of the first and second faces of the first shim (1'), the first surface of the second shim (1) and the flange surface (4) of the fixing ring (3);
preferably wherein the further pair of annular cavities are each provided with a sealing barrier.

11. An apparatus as claimed in any preceding claim, wherein the offshore foundation is a gravity foundation or a monopile.

12. An offshore structural assembly, offshore foundation, offshore assembly or offshore structure comprising the apparatus of any preceding claim.

13. A method of adjusting the level of an interface between an offshore foundation (6) and a structure (7) to be mounted thereto, the method comprising:

attaching a fixing ring (3) atop the offshore foundation;
mounting two shims (1, 1') one on top of the other atop the fixing ring; and
rotating at least one shim to correct an angle of tilt of the offshore foundation and to hence provide a generally horizontal plane for mounting the structure on the offshore foundation;
wherein each shim has a width generally transverse to the rotational axis and a depth generally in the direction of the rotational axis, and the depth of the shim varies generally linearly across the width of the shim; and
wherein a first shim (1') for mounting to the fixing ring (3) comprises a first circular groove provided in each of opposing first and second faces of the first shim (1'), said first surface for contacting the fixing ring (3) and said second surface for contacting a second shim (1), and wherein the second shim is provided with a corresponding first groove in a first face for contacting the first shim (1').

14. A method as claimed in claim 13, wherein the fixing ring (3) comprises an upper and lower flange (4, 5).

15. A method as claimed in claim 13 or claim 14, comprising:

placing a lower shim (1') atop the upper flange (4) of the fixing ring (3); rotating the lower shim (1'); placing an upper shim (1) atop the lower shim; rotating the upper shim; placing a tower atop the shims, said tower comprising a lower flange; and placing bolts through holes provided in the lower flange of the tower, the shims (1, 1') and the upper flange (4) of the fixing ring (3).

Patentansprüche

1. Vorrichtung zum Anpassen des Niveaus einer Schnittstelle zwischen einer Offshore-Gründungsstruktur (6) und einer daran zu montierenden Struktur (7), wobei die Vorrichtung umfasst:

zwei Zwischenscheiben (1, 1'), die beide im Verhältnis zur jeweils anderen und zur Offshore-Gründungsstruktur um eine Drehachse drehbar sind,
einen Befestigungsring (3) zur Montage der Zwischenscheiben (1, 1') an der Offshore-Gründungsstruktur (6),
wobei die Zwischenscheiben dafür vorgesehen sind, eine auf der anderen zwischen der Offshore-Gründungsstruktur (6) und der Struktur (7) positioniert zu werden,
wobei jede Zwischenscheibe eine Breite hat, die im Allgemeinen quer zur Drehachse ist, und eine Tiefe, die im Allgemeinen die Richtung der Drehachse hat, und die Tiefe der Zwischenscheibe im Allgemeinen linear über die Breite der Zwischenscheibe variiert; und
wobei eine erste Zwischenscheibe (1') zur Montage des Befestigungsrings (3) eine erste kreisförmige Nut umfasst, die in beiden gegenüberliegenden Flächen der ersten Zwischenscheibe (1'), der ersten und der zweiten Fläche vorgesehen ist, die erste Oberfläche zur Kontaktierung des Befestigungsrings (3) und die zweite Oberfläche zur Kontaktierung einer zweiten Zwischenscheibe (1), und wobei die zweite Zwischenscheibe mit einer entsprechenden ersten Nut in einer ersten Fläche zur Kontaktierung der ersten Zwischenscheibe (1') versehen ist.

2. Vorrichtung gemäß Anspruch 1, wobei ein Zwischenscheibenwinkel 0 einer jeden Zwischenschei-

be (1, 1'), welcher der Schnittwinkel θ der Ebenen ist, die auf die obere und die untere Oberfläche der Zwischenscheibe ausgerichtet sind, weniger als 1° beträgt, wobei der Zwischenscheibenwinkel vorzugsweise ca. 0,5° beträgt.

3. Vorrichtung gemäß Anspruch 1 oder 2, wobei ein Zwischenscheibenwinkel Θ einer jeden Zwischenscheibe, welcher der Schnittwinkel θ der Ebenen ist, die auf die obere und die untere Oberfläche der Zwischenscheibe ausgerichtet sind, identisch ist.

4. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei die Zwischenscheiben kreisförmig sind und vorzugsweise ringförmig sind.

5. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei jede Zwischenscheibe Löcher (2) umfasst, die gleichmäßig um einen Umfang der Zwischenscheibe verteilt sind, um Verbinder aufzunehmen, die die Zwischenscheiben in einer installierten Position halten.

6. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei der Befestigungsring einen Flansch (5) zur Montage der Offshore-Gründungsstruktur und einen Flansch (4) zum Tragen der Zwischenscheiben umfasst.

7. Vorrichtung gemäß Anspruch 6, wobei der Befestigungsring (3) eine kreisförmige Nut in der Flanschoberfläche (4) für einen Kontakt mit der ersten Zwischenscheibe (1') umfasst.

8. Vorrichtung gemäß Anspruch 7, wobei die Nut in der ersten Oberfläche der ersten Zwischenscheibe (1') auf die Nut in der Flanschoberfläche (4) des Befestigungsrings (3) ausgerichtet ist und wobei die Nut in der ersten Fläche der zweiten Zwischenscheibe (1) auf die Nut in der zweiten Fläche der ersten Zwischenscheibe (1') ausgerichtet ist, wobei dadurch in einer installierten Position ein Paar ringförmiger Hohlräume gebildet wird.

9. Vorrichtung gemäß Anspruch 8, wobei in jedem ringförmigen Hohlraum ein reibungsminderndes System vorgesehen ist.

10. Vorrichtung gemäß Anspruch 9, wobei der ringförmige Hohlraum mit einer dichtenden Sperre versehen ist;
oder wobei ein weiteres Paar ringförmiger Hohlräume vorgesehen ist, indem zweite Nuten in der ersten und der zweiten Fläche der ersten Zwischenscheibe (1'), der ersten Oberfläche der zweiten Zwischenscheibe (1) und der Flanschoberfläche (4) des Befestigungsrings (3) vorgesehen sind;
wobei das weitere Paar ringförmiger Nuten vorzugsweise mit einer dichtenden Sperre versehen ist.

11. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei die Offshore-Gründungsstruktur eine Schwerkraftgründung oder ein einzelner Stahlpfeiler ist.

12. Offshore-Struktur-Baugruppe, Offshore-Gründungsstruktur, Offshore-Baugruppe oder Offshore-Struktur, die eine Vorrichtung gemäß einem der vorhergehenden Ansprüche umfasst.

13. Verfahren zum Einstellen des Niveaus einer Schnittstelle zwischen einer Offshore-Gründungsstruktur (6) und einer daran zu montierenden Struktur (7), wobei das Verfahren umfasst:

Anbringen eines Befestigungsrings (3) auf der Offshore-Gründungsstruktur;
Montieren von zwei Zwischenscheiben (1, 1') übereinander auf dem Befestigungsring und
Drehen von mindestens einer Zwischenscheibe, um einen Neigungswinkel der Offshore-Gründungsstruktur zu korrigieren und so eine im Allgemeinen waagerechte Ebene für die Montage der Struktur auf der Offshore-Gründungsstruktur zu schaffen;
wobei jede Zwischenscheibe eine Breite hat, die im Allgemeinen quer zur Drehachse ist, und eine Tiefe, die im Allgemeinen die Richtung der Drehachse hat, und die Tiefe der Zwischenscheibe im Allgemeinen linear über die Breite der Zwischenscheibe variiert; und
wobei eine erste Zwischenscheibe (1') zur Montage des Befestigungsrings (3) eine erste kreisförmige Nut umfasst, die in beiden gegenüberliegenden Flächen der ersten Zwischenscheibe (1'), der ersten und der zweiten Fläche vorgesehen ist, die erste Oberfläche zur Kontaktierung des Befestigungsrings (3) und die zweite Oberfläche zur Kontaktierung einer zweiten Zwischenscheibe (1), und wobei die zweite Zwischenscheibe mit einer entsprechenden ersten Nut in einer ersten Fläche zur Kontaktierung der ersten Zwischenscheibe (1') versehen ist.

14. Verfahren gemäß Anspruch 13, wobei der Befestigungsring (3) einen oberen und unteren Flansch (4, 5) umfasst.

15. Verfahren gemäß Anspruch 13 oder 14, umfassend. Platzieren einer unteren Zwischenscheibe (1') auf dem oberen Flansch (4) des Befestigungsrings (3); Drehen der unteren Zwischenscheibe (1'); Platzieren einer oberen Zwischenscheibe (1) auf der unteren Zwischenscheibe; Drehen der oberen Zwischenscheibe; Platzieren eines Turms auf den Zwischenscheiben, wobei der Turm einen unteren Flansch

umfasst; und Platzieren von Bolzen durch Löcher, die im unteren Flansch des Turms, den Zwischenscheiben (1, 1') und dem oberen Flansch (4) des Befestigungsrings (3) vorgesehen sind.

Revendications

1. Appareil pour l'ajustage du niveau d'une interface entre des fondations sous-marines (6) et une structure (7) devant être montée sur celles-ci, l'appareil comprenant :

   deux cales (1, 1') chacune pouvant tourner autour d'un axe de rotation par rapport à l'autre et aux fondations sous-marines,
   une bague de fixation (3) pour le montage des cales (1, 1') sur les fondations sous-marines (6), les cales étant conçues pour être montées l'une au-dessus de l'autre entre les fondations sous-marines (6) et la structure (7),
   chaque cale présentant une largeur dans l'ensemble transversale à l'axe de rotation, et une largeur généralement dans la direction de l'axe de rotation, et la profondeur de la cale variant de façon généralement linéaire à travers la largeur de la cale ; et
   une première cale (1') à monter sur la bague de fixation (3) comprenant une première cannelure circulaire placée dans chacune des première et deuxième faces opposées de la première cale (1'), ladite première surface étant au contact de la bague de fixation (3), et l'autre surface étant au contact d'une deuxième cale (1), et la deuxième cale étant dotée d'une première cannelure correspondante dans une première face au contact de la première cale (1').

2. Appareil selon la revendication 1, un angle de cale θ de chaque cale (1.1'), à savoir l'angle θ de l'intersection de plans alignés avec des surfaces supérieure et inférieure de la cale, étant inférieur à 1°, l'angle de cale étant de préférence égal à environ 0,5°.

3. Appareil selon la revendication 1 ou 2, un angle de cale θ de chacune des cales, à savoir l'angle θ de l'intersection de plans alignés avec des surfaces supérieure et inférieure de la cale, étant identique.

4. Appareil selon une quelconque des revendications précédentes, les cales étant circulaires, et de préférence annulaires.

5. Appareil selon une quelconque des revendications précédentes, chaque cale comprenant des trous (2), espacés de façon régulière sur le pourtour de la cale, dans lesquels se placent des connecteurs servant à fixer les cales dans une position installée.

6. Appareil selon une quelconque des revendications précédentes, la bague de fixation comprenant une bride (5) pour le montage sur les fondations sous-marines et une bride (4) supportant les cales.

7. Appareil selon la revendication 6, la bague de fixation (3) comprenant une cannelure circulaire dans la surface de la bride (4) pour le contact avec la première cale (1').

8. Appareil selon la revendication 7, la cannelure dans la première surface de la première cale (1') étant alignée avec la cannelure dans la surface de la bride (4) de la bague de fixation (3), et la cannelure dans la première face de la deuxième cale (1) étant alignée avec la cannelure dans la deuxième face de la première cale (1'), une paire de cavités annulaires étant ainsi formée dans une position installée.

9. Appareil selon la revendication 8, un système de réduction de la friction étant fourni dans chaque cavité annulaire.

10. Appareil selon la revendication 9, la cavité annulaire étant dotée d'une barrière d'étanchéité ;
    ou une paire additionnelle de cavités annulaires étant pratiquée en plaçant des deuxièmes cannelures dans chacune des première et deuxième faces de la première cale (1'), la première surface de la deuxième cale (1) et la surface de la bride (4) de la bague de fixation (3) ;
    de préférence chaque cavité de la paire additionnelle de cavités annulaires étant dotée d'une barrière d'étanchéité.

11. Appareil selon une quelconque des revendications précédentes, les fondations sous-marines étant des fondations par gravité ou un mono-pieu.

12. Ensemble structurel sous-marin, des fondations sous-marines, un ensemble sous-marin ou une structure sous-marine comprenant l'appareil selon une quelconque des revendications précédentes.

13. Méthode d'ajustage du niveau d'une interface entre des fondations sous-marines (6) et une structure (7) à monter sur celles-ci, la méthode comprenant :

    la fixation d'une bague de fixation (3) sur le dessus des fondations sous-marines ;
    le montage de deux cales (1, 1'), l'une au-dessus de l'autre, sur la bague de fixation ; et
    la rotation d'au moins une cale pour rectifier un angle d'inclinaison des fondations sous-marines et permettre ainsi d'obtenir un plan généralement horizontal pour le montage de la struc-

ture sur les fondations sous-marines ;
chaque cale présentant une largeur généralement transversale à l'axe de rotation, et une profondeur généralement dans la direction de l'axe de rotation et la profondeur de la cale variant de façon généralement linéaire à travers la largeur de la cale ; et
une première cale (1') pour le montage sur la bague de fixation (3) comprenant une première cannelure circulaire pratiquée dans chacune des première et deuxième faces opposées de la première cale (1'), ladite première surface étant au contact de la bague de fixation (3) et ladite deuxième surface étant au contact d'une deuxième cale (1), et la deuxième cale étant dotée d'une première cannelure correspondante dans une première face pour être au contact de la première cale (1').

14. Méthode selon la revendication 13, la bague de fixation (3) comprenant une bride supérieure et une bride inférieure (4, 5).

15. Méthode selon la revendication 13 ou la revendication 14, comprenant :

le placement d'une cale inférieure (1') sur la bride supérieure (4) de la bague de fixation (3) ; la rotation de la cale inférieure (1') ; le positionnement d'une cale supérieure (1) sur la cale inférieure ; la rotation de la cale supérieure ; le positionnement d'une tour sur les cales, ladite tour comprenant une bride inférieure ; et l'installation de boulons dans les trous pratiqués dans la bride inférieure de la tour, les cales (1, 1), et la bride supérieure (4) de la bague de fixation (3).

Fig. 1

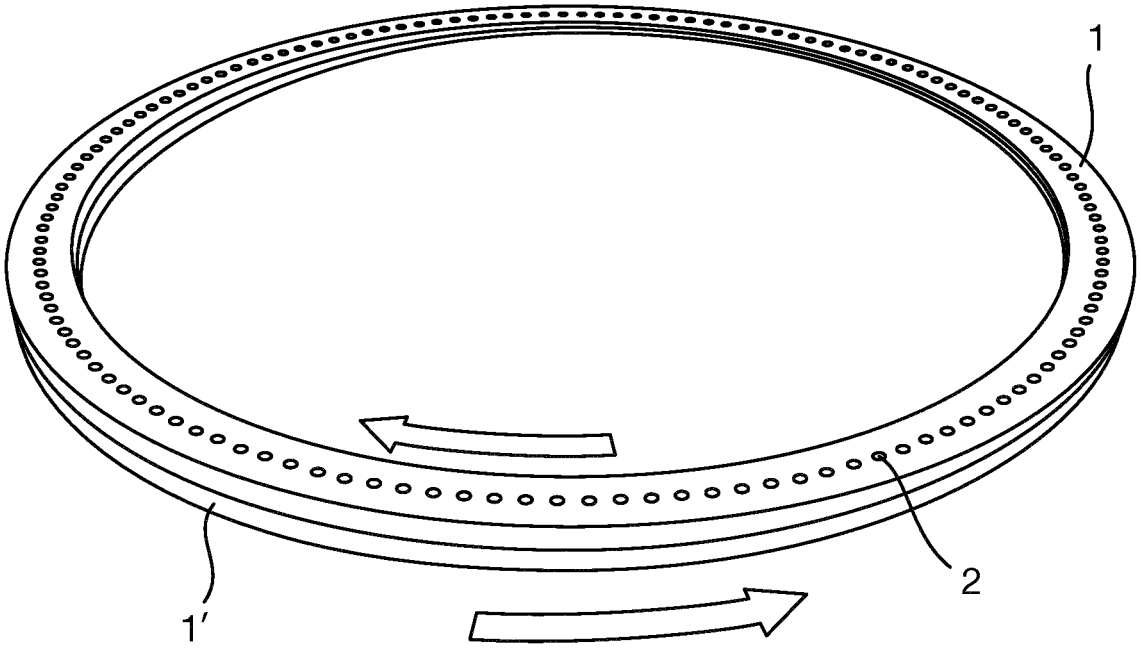


Fig. 2

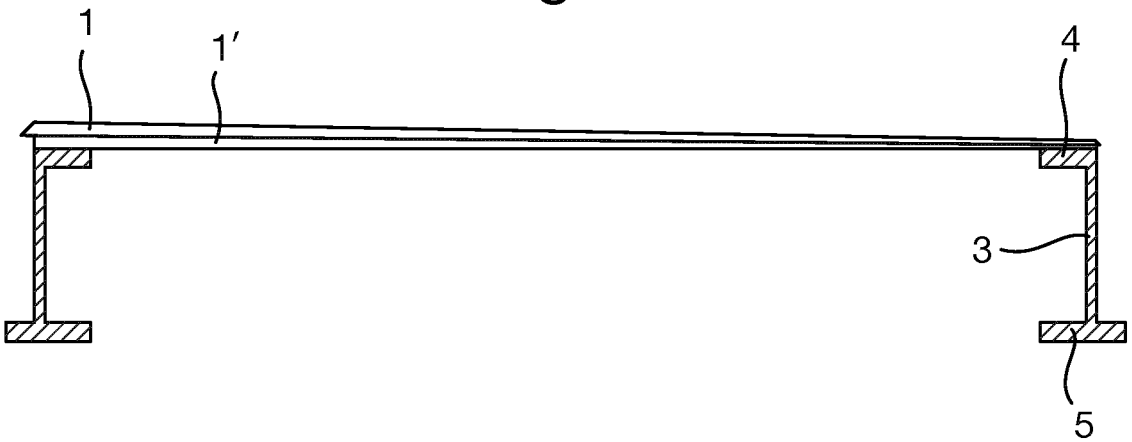
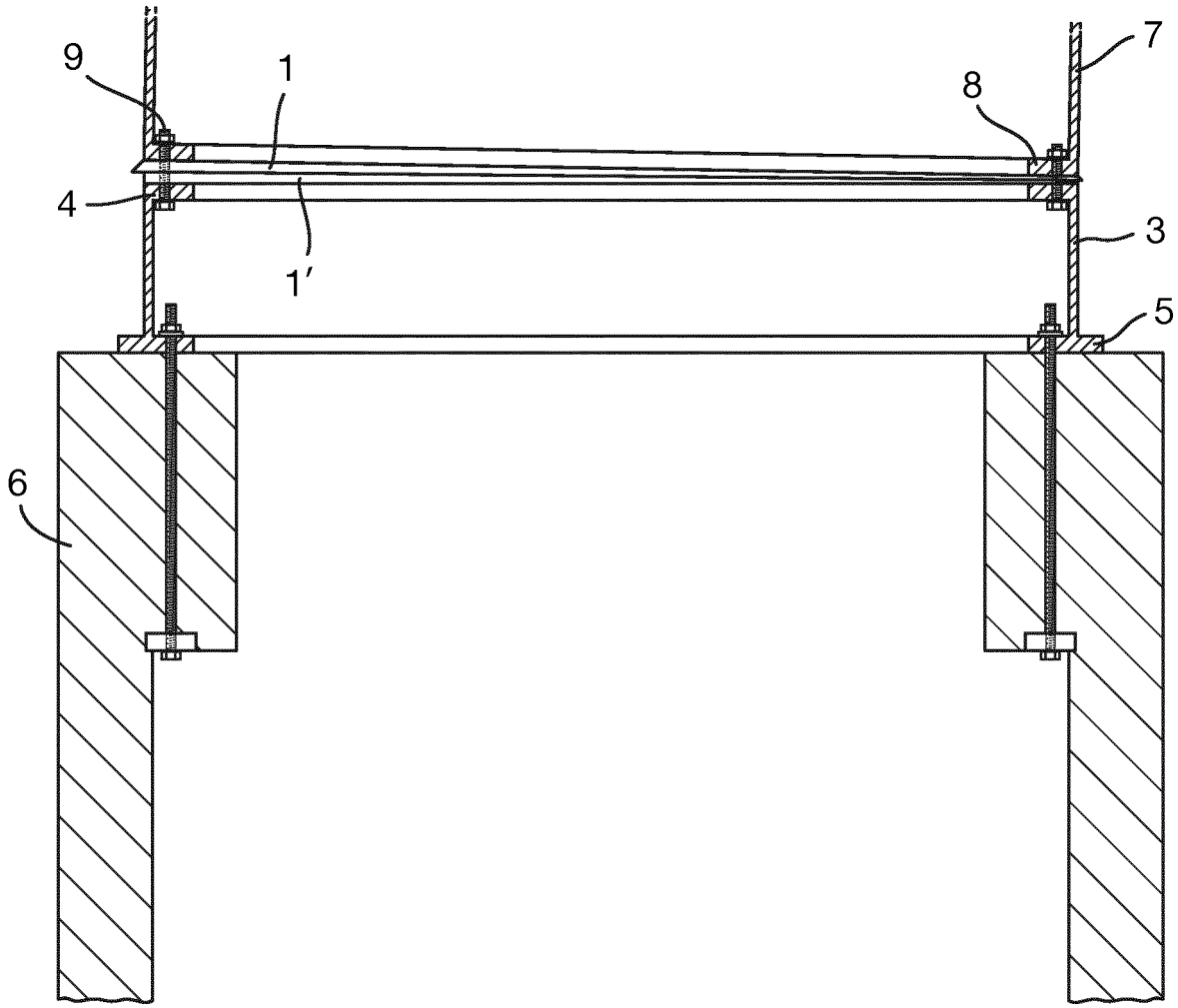


Fig. 3



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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