MOORING ASSEMBLY

FIELD OF THE INVENTION

The present invention relates to mooring assembly for attaching a vessel to a subsea well. The present invention also relates to a method for fitting a mooring assembly for a vessel to a subsea well as well as a method for mooring a vessel to a subsea well, wherein, when moored, the vessel is capable of rotational movement around the subsea well. The mooring assembly allows for control of and production from the well to the vessel.

BACKGROUND TO THE INVENTION

The cost of current solutions for exploiting natural resources in the oil and gas sector means that many smaller scale oil and gas fields cannot be developed economically.

The present invention seeks to provide a solution that will safely enable the commercialisation of smaller scale oil and gas fields by allowing for a well to be produced without many of the components that are traditionally required.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a mooring assembly for attaching a vessel to a subsea well including a well conductor, the mooring assembly comprising:

(a) a housing adapted to be fixed to~~for~~ the well conductor and including a rotatably mounted vessel attachment point extending laterally therefrom; and

(b) a base defining an interface for a subsea ground surface; and

~~(c) a rotatably mounted vessel attachment point;~~

wherein, in use, a vessel moored to the subsea well is capable of rotational movement around the subsea well.

In accordance with a second aspect of the present invention, there is provided a method ~~for~~ of fitting a mooring assembly according to a first aspect, to a subsea

well including a well conductorfor a vessel to a subsea well including a well conductor, the method comprising the steps of:

(a) providing the mooring assembly including a base; and

(b) rotatably mounting the mooring assembly to the well conductor at or near a subsea ground surface;

wherein, in use, a vessel moored to the subsea well is capable of rotational movement around the subsea well.

In accordance with a third aspect of the present invention, there is provided a method of for mooring a vessel to a subsea well, the method comprising the step of attaching the vessel to the subsea well via a mooring assembly as described herein and wherein, when moored, the vessel is capable of rotational movement around the subsea well.

It is to be recognised that other aspects, preferred forms and advantages of the present invention will be apparent from the specification including the detailed description, examples, drawings and claims provided below.

BRIEF DESCRIPTION OF DRAWINGS

In order to facilitate a better understanding of the present invention, preferred embodiments are described herein with reference to the accompanying drawings, in which:

Figure 1A is a side view of a mooring assembly according to a first embodiment of the first aspect of the subject invention;

Figure 1B is a top view of the mooring assembly of Figure 1A;

Figure 1C is perspective view of the mooring assembly of Figure 1A including a partial cut away section to show further detail of the mooring assembly;

Figure 2A is a side view of a mooring assembly according to a second embodiment of the first aspect of the subject invention;

Figure 2B is a top view of the mooring assembly of Figure 2A;

Figure 2C is perspective view of the mooring assembly of Figure 2A including a partial cut away section to show further detail of the mooring assembly;

Figure 2D is cross sectional view A-A in Figure 2B

Figures 3A-3H are a sequence of schematic drawings to illustrate a method for fitting a mooring assembly for a vessel to a subsea well according to one embodiment of the second aspect of the subject invention;

Figures 3I and 3J illustrate a production well fitted with the mooring assembly in Figure 3H incorporating a flow controller (christmas tree) and a mooring line (Figure 3J) for attachment to a floating production vessel; and

Figure 4 is a perspective view including a partial cut away showing the mooring assembly of Figure 1A as part of a production well.

DETAILED DESCRIPTION OF THE INVENTION

According to a first aspect of the present invention, there is provided a mooring assembly for attaching a vessel to a subsea well including a well conductor, the mooring assembly comprising:

(a) a housing adapted to be fixed to~~for~~ the well conductor and including a rotatably mounted vessel attachment point extending laterally therefrom; and

(b) a base defining an interface for a subsea ground surface; and

~~(c) a rotatably mounted vessel attachment point;~~

wherein, in use, a vessel moored to the subsea well is capable of rotational movement around the subsea well.

For the purposes of the present invention the term “well conductor” may comprise any well conduit, housing, pipe or any other similar component adapted to provide the primary support structure of a subsea well and includes a conductor pipe or conductor casing located at or near the wellbore. The well conductor may include a portion that is located above the wellbore at the subsea surface hole. The well conductor may also include a portion that is

located below the wellbore.

Preferably, the well conductor comprises a conductor pipe or conductor casing.

Preferably, the mooring assembly defines a single mooring point on the seabed.

The mooring assembly may be adapted to allow a vessel moored thereto to weather vane through 360 degrees. Preferably, the mooring assembly is adapted to allow for a vessel moored thereto to weather vane in either direction.

Preferably, the mooring assembly comprises a guide base such as permanent guide base.

Preferably, the housing defines a conduit for the well conductor.

Preferably, the conduit is centrally located in the housing.

Preferably, the conduit comprises a circular cross section.

Preferably, the conduit defines an upper end and a lower end and an inner surface therebetween with a profile that is sized and shaped to allow the housing to form a sleeve or sheath around the well conductor.

~~Preferably, the housing comprises fixing means to enable it to be fixed in position relative to the well conductor.~~

Preferably, the housing is adapted to be fixed in position relative to the well conductor by a fixing means for forming a frictional engagement between~~is adapted to allow~~ the housing and the well conductor~~ to form a frictional engagement~~. Even more preferably, the fixing means comprises a first mating surface provided on the housing and is compatible with a second mating surface on the well conductor. In one particular form of the invention a first mating surface is provided on the inner surface of the housing and is compatible with a second mating surface provided on the outside surface of the well conductor. The first mating surface can comprise a pin, a ball, a bore, a projection, a blade or a channel.

Preferably, the first mating surface is compatible with the second mating surface comprising a pin, a ball, a bore, a projection, a blade or a channel.

Preferably, the housing further comprises a locating means for locating a well casing therein. In this regard, when installing a well casing from above, the locating means makes it easier to land and install the well casing or at least assists with guiding the well casing into the wellbore.

Preferably, the well casing is a well surface casing.

Preferably, the locating means is adapted to centre the well casing in the housing, or, when the housing comprises a conduit, in the conduit.

Preferably, the locating means is provided integrally with the conduit.

Preferably, the locating means is located at or towards the upper end of the conduit.

Preferably, the locating means comprises a contact surface for the leading end of the well casing and extends outwardly from the inner surface of the conduit.

The contact surface may extend around the entirety of the upper end of the conduit or extend around a part of the upper end of the conduit.

Preferably, the locating means comprises a projection such as a lip or shoulder.

Preferably, the locating means comprises a circumferential projection.

Preferably, the housing further comprises a guide means to further assist with landing a casing in the housing.

Preferably, the guide means comprises a body defining a bore with a wider opening than the opening at the upper end of the conduit.

Preferably, the guide means comprises a tube, funnel, drum funnel or bucket member.

Preferably, the guide means is located immediately adjacent to and above the locating means. Even more preferably, the guide means and the locating means are provided integrally.

Preferably, the housing defines a mounting point for the rotatably mounted vessel attachment point. Preferably, the mounting point is located on the outer surface of the conduit. Preferably, the mounting point is a suitably sized and

shaped surface that is compatible with the rotatably mounted vessel attachment point.

Preferably, the base comprises at least one engaging means for the subsea ground surface. Even more preferably, the base comprises a plurality of said engaging means.

The engaging means for the subsea ground surface at least limits the movement, such as lateral and/or rotational movement, of the base relative to the subsea ground surface. Preferably, the engaging means fixes the mooring assembly in position relative to the subsea ground surface. In this regard, it is preferred that the engaging means locks the mooring assembly to the subsea ground surface ~~e.g.~~e.g., seabed such that it cannot rotate, move axially (pull-out) or laterally (tilt).

Preferably, the engaging means for the subsea ground surface are arranged around the base. Even more preferably, said engaging means are arranged equidistantly apart around the base.

Preferably, the engaging means for the subsea ground surface comprises a projection such as a foot, leg, stab or blade.

The engaging means for the subsea ground surface may comprise at least one arm or strut that extends laterally from the base to allow the interface to extend over a larger area of subsea ground surface. When said engaging means comprises an arm or strut, the projection maybe provided at or near the distal end of the arm or strut.

Preferably, the engaging means for the subsea ground surface is adapted to penetrate the subsea ground surface, when in use. Alternatively, the engaging means for the subsea ground surface may be adapted to receive additional anchoring elements, such as a stake, pile, screw or a spike to increase the strength of the engagement with the subsea ground surface.

The base may comprise a spacing means to allow the formation of void between the base and the subsea ground surface, when in use.

The spacing means may be the projection or an additional feature of the base.

Preferably, the spacing means extends from the lowermost surface of the base.

The void allows for the cement returning to the surface, when cementing a well conductor therein, to be visually confirmed.

When no void is formed or the returning cement cannot otherwise be visually confirmed, the housing may further comprise at least one inspection port or observation window to allow for the cement return to be confirmed.

Preferably, the void or inspection port is adapted to allow for the passage of a fixing material, such as mortar, glue or concrete to an area adjacent to a lower portion of the base. Preferably, said area is one or more of the areas between the base and the subsea ground surface, the base and another feature of the mooring assembly and/or the base and the subsea well, such as the well conductor.

Preferably, the base comprises a skirt that extends out radially from the main longitudinal axis of the housing. Preferably, the skirt is located at the lower end of the conduit and is provided integrally with one or more of the conduit, the engaging means and/or the spacing means.

Preferably, the base acts to reinforce the mooring assembly and/or performs a supporting role for at least one other component of the mooring assembly, such as the rotatably mounted vessel attachment point and more particularly the bearing member, described in more detail hereunder.

Preferably, the rotatably mounted vessel attachment point is mounted to the housing. Even more preferably, the rotatably mounted vessel attachment point is mounted to the housing at a point below the locating means.

Preferably, the rotatably mounted vessel attachment point comprises at least one bearing member. Even more preferably, the rotatably mounted vessel attachment point comprises a plurality of bearing members.

Preferably, the bearing member defines a tapered bearing surface.

Preferably, the tapered bearing surface tapers in towards its lower end.

Preferably, the bearing member is a roller bearing such as a conical roller

bearing or roller cone bearing.

Preferably, the bearing member includes at least one port, such as a port accessible by a ROV, for the delivery of lubricant to the at least one bearing member.

Preferably, the rotatably mounted vessel attachment point comprises an attachment member for releasably receiving a vessel anchor line or hawser.

Preferably, the attachment member comprises a padeye, loop or shackle.

Preferably, the rotatably mounted vessel attachment point comprises at least one extension arm between the bearing member and the attachment member to provide for lateral spacing between the attachment member and the bearing member. Even more preferably, the rotatably mounted vessel attachment point comprises two arm members.

Preferably, the mooring assembly is fitted to a subsea well, wherein the subsea well further comprises a flow controller and wherein the rotatably mounted vessel attachment point is adapted to rotate independently of the flow controller.

According to a second aspect of the present invention, there is provided a method for fitting a mooring assembly according to the first aspect~~for a vessel to a subsea well including a well conductor~~, the method comprising the steps of

(a) providing the mooring assembly ~~including a base~~; and

(b) rotatably mounting the mooring assembly to the well conductor at or near a subsea ground surface;

wherein, in use, a vessel moored to the subsea well is capable of rotational movement around the subsea well.

Preferably, the mooring assembly is the mooring assembly described herein.

Preferably, the mooring assembly is mounted to the well conductor by landing it thereon.

Preferably, the mooring assembly is frictionally engaged with or affixed or

fastened to the well conductor.

Preferably, the mooring assembly is rotatably mounted to the well conductor such that it defines a void at an interface between the base and the subsea ground surface or otherwise allows for cement returning to the subsea ground surface, when cementing a well conductor therein, to be visually confirmed.

Preferably, the method further comprises the step of fixing the mooring assembly to the well conductor. Preferably, the step of fixing the mooring assembly to the well conductor comprises latching or otherwise securely fastening the mooring assembly to the well conductor.

Preferably, the method further comprises the step of extending the well conductor by fitting another well casing to the mooring assembly.

Preferably, the method further comprises the step of fitting a flow control means, such as christmas tree, to the well conductor.

According to a third aspect of the present invention, there is provided a method ~~for~~ of mooring a vessel to a subsea well, the method comprising the step of attaching the vessel to the subsea well via a mooring assembly as described herein and wherein, when moored, the vessel is capable of rotational movement around the subsea well.

General

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. The invention includes all such variation and modifications. The invention also includes all of the steps and features referred to or indicated in the specification, individually or collectively and any and all combinations or any two or more of the steps or features.

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in this text is merely for reasons of conciseness. None of the cited material or the information contained in that material should, however be understood to be common general knowledge.

The present invention is not to be limited in scope by any of the specific embodiments described herein. These embodiments are intended for the purpose of exemplification only. Functionally equivalent products and methods are clearly within the scope of the invention as described herein.

The invention described herein may include one or more range of values (~~e.g.~~e.g., size etc). A range of values will be understood to include all values within the range, including the values defining the range, and values adjacent to the range which lead to the same or substantially the same outcome as the values immediately adjacent to that value which defines the boundary to the range.

Throughout this specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Other definitions for selected terms used herein may be found within the detailed description of the invention and apply throughout. Unless otherwise defined, all technical terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which the invention belongs.

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A mooring assembly according to one embodiment of the first aspect of the

invention is generally indicated by the numeral 10 in Figures 1A to 1C and comprises a housing for the well conductor that defines a centrally located conduit 12 with a circular cross section 14. The conduit 12 has an upper end 16 and a lower end 18 and an inner surface therebetween 20 with a profile sized and shaped to receive a standard well conductor with a circular cross section, such as a surface casing. The mooring assembly 10 can be fitted on an installed well conductor by passing the free end of the well conductor to form a sleeve arrangement over the well conductor.

The housing includes a fixing means (not shown), to enable it to be fixed in position relative to the well conductor, in the form of a first mating surface (not shown) on the inner surface 20 that is configured to mate with a second mating surface on the outside surface of the well conductor (not shown).

The housing further comprises a locating means, for locating a casing therein, in the form of a shoulder 22 provided integrally with and located at the upper end 16 of the conduit 12. The shoulder 22 projects circumferentially from and extends around the entirety of the upper end 16 of the conduit 12.

The housing further comprises a guide means in the form of a cup shaped body 24 that is provided integrally with and located adjacent to and above the shoulder 22. The cup shaped body 24 defines a bore with a wider opening and cross section that the cross section 14 of the conduit 12.

The mooring assembly further comprises a base 26 defining an interface for a subsea ground surface. The base 26 includes a skirt 28 that extends radially from the main longitudinal axis of the conduit 12 and is provided integrally with the lower end 18 of the conduit 12 and the engaging means in the form of a plurality of blades 30 including feet 32 that extend downwards from the skirt 28 and are adapted to penetrate the subsea ground surface, when in use. The blades 30, including feet 32, are arranged and equidistantly spaced around the skirt 28.

The blades 30 including feet 32 also form a spacing means to allow the formation of void between the skirt 28 and the subsea ground surface when in

use. The void 34 is best depicted in Figure 3C and allows for the return of fixing material, such as concrete to be visualised during the installation process (see Figures 3A-3J).

The mooring assembly 10 further comprises a rotatably mounted vessel attachment point in the form of a pair of extension arms 36a, 36b that are mounted to the conduit 12 at one end via a bearing member in the form of upper and lower radial bearings 38a, 38b that are housed in bearing case 40. The other end of the extension arms 36a, 36b are attached to an attachment member for releasably receiving a vessel anchor line or hawser in the form of padeye 42.

A mooring assembly according to another embodiment of the first aspect of the invention is generally indicated by the numeral 100 in Figures 2A to 2D. This embodiment includes many features corresponding to features in the first embodiment and such corresponding features have been referred to in Figures 2A-2D with corresponding numbers used in Figures 1A-1C.

The main difference in the embodiment depicted in Figures 2A-2D is at the interface for the subsea ground surface. The base 26 includes a skirt 28 that extends radially from the main longitudinal axis of the conduit 12 and is provided integrally with the lower end 18 of the conduit 12 as in the embodiment in Figures 1A-1C. However, the engaging means is in the form of a plurality of modified blades 130 that extend downwards from the skirt 28 in combination with three equally spaced arms 150a, 150b and 150c that extends laterally from the base 26 to allow the interface to extend over a larger area of subsea ground surface. Each of the distal ends of arms 150a, 150b and 150c include projections in the form of feet 152a, 152b and 152c that define eyelets 154a, 154b and 154c adapted to receive additional anchoring elements, such as a stake, pile or a spike.

In a similar fashion to the first embodiment in Figures 1A-1C, in the later embodiment, the blades 30 and feet 152a-c form a spacing means to allow the formation of void between the skirt 28 and the subsea ground surface when in

use to allow for the return of fixing material, such as cement or concrete, to be viewed during the installation process (see Figures 3A-3J). If the mooring assembly is flush with the subsea ground ~~surface~~surface, then the housing may further comprise at least one inspection or observation port to enable the returning fixing material or grout to be viewed during the installation process.

Figures 3A-3J depict a method of fitting a mooring assembly according to one embodiment of the second aspect of the present invention.

Following drilling of a hole in a subsea surface 60 (Figure 3A) and introducing a well conductor 62 therein (Figure 3B), a mooring assembly, generally indicated by the numeral 110 is landed on the well conductor 62 at or near the subsea surface 60 (Figure 3C). A spacing means (not shown) in the mooring assembly 110 allows for the formation of a void 34 (Figure 3C), between the mooring assembly 110 and the subsea ground surface 60, to allow for the viewing of the return of a fixing material such as concrete or cement 112 injected to fix the well conductor 62 into the seabed or rock layers in the top hole (Figure 3D). The cement 112 extends down into the hole to ensure a strong engagement between the mooring assembly 110 and the well conductor 62.

Once the mooring assembly 110 and well conductor are cemented other well casings, such as a surface casing 114, can be installed via the upper end of the well conductor 62 (Figure 3E) and further drilling (Figure 3F) and attachment of further casings, such as intermediate casing 116 (Figure 3G) can be installed as per a conventional drilling operation. Finally, production tubing 118 (Figure 3H) and a flow controller such as a christmas tree 120 (Figure 3I) can be fitted to configure the well for production.

Once the installation is completed (Figure 3H) the well can be harvested from a floating production vessel (not shown), at the sea surface, moored via line 122 to the well conductor 62 via mooring assembly 110 (Figures 3I and 3J). Whilst attached to the mooring assembly 110, the vessel is free to move, rotate or “weather vane” around the subsea well.

Figure 4 is a schematic diagram including a cut away section and illustrates the mooring assembly 10 according to the first embodiment as part of a production well that includes a flow controller ~~i.e.~~i.e., christmas tree 120 connected to the casing via a wellhead connector 180. Features from earlier figures that are included in Figure 4 use the same reference numerals.

CLAIMS

1. A mooring assembly for attaching a vessel to a subsea well including a well conductor, the mooring assembly comprising:

   (a) a housing adapted to be fixed to~~for~~ the well conductor and including a rotatably mounted vessel attachment point extending laterally therefrom; and

   (b) a base defining an interface for a subsea ground surface; ~~and~~

   ~~(c) a rotatably mounted vessel attachment point;~~

   wherein, in use, a vessel moored to the subsea well is capable of rotational movement around the subsea well.

2. A mooring assembly according to claim 1 wherein the well conductor comprises a conductor pipe or conductor casing.

3. A mooring assembly according to claim 1 or 2 adapted to allow a vessel moored thereto to weather vane through 360 degrees.

~~2.~~4. A mooring assembly according to any one of the preceding claims ~~1~~ wherein the housing defines a conduit for the well conductor.

5. A mooring assembly according to claim 4 wherein the conduit defines an upper end and a lower end and an inner surface therebetween with a profile that is sized and shaped to allow the housing to form a sleeve or sheath around the well conductor.

~~3. A mooring assembly according to any one of the preceding claims wherein the housing comprises fixing means to enable it to be fixed in position relative to the well conductor.~~

6. A mooring assembly according to any one of the preceding claims wherein the housing is adapted to be fixed in position relative to the well conductor by a fixing means for forming a frictional engagement between the housing and the well conductor.

~~4.~~7. A mooring assembly according to claim ~~6~~3 wherein the fixing means comprises a first mating surface provided on the housing that is

compatible with a second mating surface on the well conductor.

~~5.~~8. A mooring assembly according to claim 7~~4~~ wherein the first mating surface comprises a pin, a ball, a bore, a projection, a blade or a channel.

9. A mooring assembly according to claims 7 or 8 wherein the second mating surface comprises a pin, a ball, a bore, a projection, a blade or a channel.

~~6.~~10.A mooring assembly according to any one of the preceding claims wherein the housing further comprises a locating means for centring a well casing therein.

11. A mooring assembly according to claim 10 wherein the housing comprises a conduit and the locating means is adapted to centre the casing in the conduit.

~~7.~~12.A mooring assembly according to any one of the preceding claims wherein the housing further comprises a guide means to further assist with landing a well casing in the housing.

~~8.~~13.A mooring assembly according to any one of the preceding claims ~~1 to 7~~ wherein the base comprises at least one engaging means for the subsea ground surface.

~~9.~~14.A mooring assembly according to claim 13~~8~~ wherein the engaging means for the subsea ground surface comprises a projection.

~~10.~~15.A mooring assembly according to claims 13~~8~~ or 14~~9~~ wherein the engaging means for the subsea ground surface comprises at least one arm or strut that extends laterally from the base to allow the interface to extend over a larger area of subsea ground surface.

~~11.~~16.A mooring assembly according to any one of claims 13~~8~~ to 15~~10~~ wherein the engaging means for the subsea ground surface is adapted to receive an additional anchoring element.

~~12.~~17.A mooring assembly according to claim 16~~11~~ wherein the additional anchoring element is a stake, pile, screw or a spike.

~~13.~~18.A mooring assembly according to any one of the preceding claims

wherein the base further comprises a spacing means to allow the formation of a void between the base and the subsea ground surface, when in use.

~~14.~~19. A mooring assembly according to claim 18~~13~~ wherein the void is adapted to allow for the passage of a fixing material~~, such as mortar, glue, cement or concrete~~ to an area adjacent to a lower portion of the base.

~~15.~~20. A mooring assembly according to any one of the preceding claims wherein the base comprises a skirt or at least one arm that extends out radially from the main longitudinal axis of the housing.

~~16.~~21. A mooring assembly according to any one of the preceding claims wherein the rotatably mounted vessel attachment point comprises at least one bearing member that defines a bearing surface.

~~17.~~22. A mooring assembly according to any one of the preceding claims wherein the rotatably mounted vessel attachment point comprises an attachment member for releasably receiving a vessel anchor line or hawser.

23. A mooring assembly according to any one of the preceding claims fitted to a subsea well, wherein the subsea well further comprises a flow controller and wherein the rotatably mounted vessel attachment point is adapted to rotate independently of the flow controller.

~~18.~~24. A method of~~for~~ fitting a mooring assembly according to any one of the preceding claims, to a subsea well including a well conductor~~for a vessel to a subsea well including a well conductor~~, the method comprising the steps of:

(a) providing the mooring assembly~~ including a base~~; and

(b) rotatably mounting the mooring assembly to the well conductor at or near a subsea ground surface;

wherein, in use, a vessel moored to the subsea well is capable of rotational movement around the subsea well.

~~19. A method according to claim 18 further comprising the step of fixing the mooring assembly to the well conductor.~~

~~20.~~25. A method off~~or~~ mooring a vessel to a subsea well, the method comprising the step of attaching the vessel to the subsea well via a mooring assembly according to any one of claims 1 to 23~~17~~ and wherein, when moored, the vessel is capable of rotational movement around the subsea well.