

AUTOMATED RISER BELL MOUTH

FIELD OF THE INVENTION

The present invention relates to an apparatus for coupling a riser to a flowline, especially when coupled to the side or a turret of a floating storage or production vessel. In particular, the present invention relates to a riser bell mouth that can
5 be used for multiple types of riser lines.

BACKGROUND ART

In deep water oil and gas exploration, flexible risers are crucial in fluid flow ducts for offshore engineering. A spread mooring floating production storage and
10 offloading (FPSO) vessel typically has a riser balcony where equipment is installed, and on the riser balcony, equipment is installed to pull the risers from the seabed/buoy and connect it to the FPSO, and oil/gas will flow through the riser line and into the FPSO for further production and storage. Beneath the balcony, bell mouths/riser I-tubes, which provide riser hang-off so that riser lines
15 can be connected to a flowline, are installed.

A number of systems have been developed for riser hang-offs to link flexible risers to the FPSO and an example is shown in Figure 1 from US 6,631,745. This system has a flexible joint 020A hung at the bell mouth 010A which is permanently connected to support 002 that sits on the hull 001.

20 One problem is that the angular allowance of existing system depends on the flexible joint or ball joint capacity as the angle of the flexible joint towards the bell mouth or fixed support cannot be changed. Typically, the angle of each bell mouth or fixed support is calculated and designed for a specific line of riser, and once designed and fabricated, it cannot be used for another riser line or another
25 location without having to refabricate the bell mouth or fixed support.

The other issue is that a typical system would require flame cutting and welding in order to effect a change of riser lines, which would lead to a change in the riser pull up angle as well. Because of this, the previous bell mouth cannot be used for the new riser lines, and may have to be cut off depending on the

circumstances, and a new bell mouth with an appropriate riser angle needs to be welded. Such orientation of lines can change as the end position of the riser on the seabed module changes.

5 The present invention seeks to provide an apparatus that alleviates the above mentioned drawbacks at least in part.

SUMMARY OF THE INVENTION

Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, and the like, are to be construed as non-
10 exhaustive, or in other words, as meaning “including, but not limited to”.

The above and other problems are solved and an improvement in the art is made by an apparatus in accordance with this invention. A first advantage of the apparatus in accordance with this invention is that the bell mouth would be suitable for engaging different lines of risers or even different operation sites
15 without having to refabricate the bell mouth. The adjustable bell mouth ensures that the bell mouth is able to accommodate different riser lines. A second advantage of the apparatus in accordance with this invention is that the bell mouth would be adjustable remotely to dispense with the need for manual modification of the bell mouth and hence there would be no need for divers. A
20 third advantage of the apparatus in accordance with this invention is that it dispenses with the need for hot processes such as flame cutting and welding when the connected riser line needs to be changed.

In accordance with an aspect of the invention there is an apparatus for connecting with a riser line, the apparatus comprising a bell mouth having a
25 cross section that allows the riser line to pass through, where the orientation of the bell mouth is adjustable by at least one actuator to accommodate the riser line. Preferably, the actuator is operable to actuate the bell mouth to adjust the azimuth angle of the bell mouth to accommodate the riser line. Alternatively, the actuator is operable to actuate the bell mouth to adjust the top angle of the
30 bell mouth to accommodate the riser line. Further alternatively, the actuator is

locally/remotely controlled. Further preferably, the apparatus has a plurality of actuators for actuating the bell mouth. Even further preferably, at least one actuator is operable to actuate the bell mouth to adjust the azimuth angle to accommodate the riser line, and at least one actuator operable to actuate the bell mouth to adjust the top angle to accommodate the riser line. Preferably, the apparatus also has a locking mechanism for locking the bell mouth in position. Further preferably, the apparatus has a first locking mechanism for locking the azimuth angle of the bell mouth and a second locking mechanism for locking the top angle of the bell mouth. Alternatively, the apparatus has a bell mouth support base and a locking cover operable to secure the bell mouth to the bell mouth support base. Preferably, the locking mechanism is mountable on the locking cover. Further preferably, the apparatus also has a clamp for preventing any movement of the riser line.

15 BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows existing bell mouth interfaces for a steel catenary riser used for FPSOs.

20 Fig. 2A, 2B and 2C show various views an embodiment of the invention showing the adjustable top angle and azimuth angle, without a riser connected. Fig. 2C is a view of an embodiment of the invention showing the A-A cross section.

Fig. 3 is a view of an embodiment of the invention showing the B-B cross section.

25 Fig. 4 is a view of an embodiment of the invention showing the C-C cross section.

Fig. 5 is an exploded isometric view of an embodiment of the invention.

Figs. 6A and 6B are views of an embodiment of the invention showing the pivotable bell mouth assembly.

Fig. 7 is an exploded isometric view of an embodiment of the invention showing the pivotable bell mouth assembly without the bell mouth body and top wearing plate.

Fig. 8 is an enlarged view of the bell mouth body.

Figs. 9A and 9B are views of an embodiment of the invention with a steel catenary riser connected.

Other arrangements of the invention are possible and, consequently, the accompanying drawings are not to be understood as superseding the generality of the preceding description of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Particular embodiments of the present invention will now be described with reference to the accompanying drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs.

In accordance with an embodiment of the present invention there is a bell mouth disclosed as shown in Figures 2A, 2B and 2C, with enlarged section details B-B and C-C shown in Figures 3 and 4 respectively, while Figure 5 shows the exploded isometric view of the apparatus. For consistency, the same reference numerals will be used for the same parts across the various figures. A bell mouth balcony 002 is shown connected to the side or the hull 001 of the FPSO. The bell mouth outer support base 003 can be connected to the bell mouth balcony 002 by welding, using studs 008 and nuts 009 or any other methods for affixing two structures, even a combination of these methods.

A pivotable bell mouth assembly 010 is fitted inside the bell mouth outer support base 003 by a locking cover 007, which is secured to the bell mouth outer support base 003. A bottom wearing plate 005, a side wearing plate 004, and a top wearing plate 006 are installed to provide wearing resistance as well as to reduce friction. The pivotable bell mouth assembly 010 is rotatable along an axis of the bell mouth outer support base 003 by an azimuth adjustment cylinder 020. The azimuth adjustment cylinder 020 can be replaced by mechanical, hydraulic or electrical actuators by using devices such as a motor drive rack and pinion or worm gear box. If required, more than one azimuth adjustment cylinders 020 can be installed along with the appropriate actuator. In such a case, each azimuth adjustment cylinder 020 will be smaller and the azimuth adjustment can be smoother.

If needed, the adjustable bell mouth can accommodate different diameters, although it may not be practical to use different sizes of risers for a given bell mouth because of the pipe spool capacity, since the pipe spool is connected to the riser above the bell mouth to direct the flow to the FPSO for processing. This is typically solved using hang-off adapters and/or a bending stiffener.

The azimuth pushing cylinder rod clevis 021 is connected to the pivotable bell mouth assembly 010 while the azimuth pushing cylinder piston end clevis 022 is connected to the bell mouth outer support base 003. The azimuth angle adjustment "b" is achieved by extending or retracting the azimuth pushing cylinder 020. An azimuth locking cylinder 040 is mounted on the locking cover 007 with an azimuth locking pin 041 connected to a rod of the azimuth locking cylinder 040. The azimuth locking pin 041 can be engaged with azimuth locking holes 042 when the azimuth angle "b" needs to be locked. The azimuth locking cylinder 040 actuates the movement of the azimuth locking pin 041 where the rod of the azimuth locking cylinder 040 can extend and/or retract from the barrel of said cylinder 040. Such extension and retraction can be effected by means known in the art, which include but are not limited to hydraulic/ pneumatic pressure. Two top adjustment cylinders 030 (one is not shown) connected with the pivotable bell mouth assembly 010 are used to achieve a top angle

adjustment "a" of the bell mouth body 011. Depending on the application, only one top adjustment cylinder 030 may be used and can be placed in a suitable location, for example, the centre of the bell mouth assembly 010. It will be appreciated that more than two top adjustment cylinders 030 may also be used.

5 The top adjustment cylinders 030 are preferably actuated by hydraulic/pneumatic pressure, although other forms of actuations such as electrical and mechanical actuations are possible. A top locking cylinder 050 mounted inside the pivotable bell mouth assembly 010 can set engagement or disengagement of the top locking pin 051 to the top locking holes 054 in the top
10 locking plate 052. The top locking plate 052 is fixed to the bell mouth body 011. The top locking cylinder 050 locks the top angle adjustment "a" of the bell mouth body 011 to a desired angle. This is to ensure that the bell mouth is safe from unwanted motion after a riser is connected. The actuation of the top locking cylinder 050 is preferably by hydraulic/ pneumatic pressure, although other
15 forms of actuations such as electrical and mechanical actuations are possible. Changes in the top angle adjustment "a" and azimuth angle adjustment "b" will change the orientation of the bell mouth body 010 with respect to the bell mouth outer support base 003 and the hull 001.

The piston ends of the top adjustment cylinders 030 are connected to the top
20 adjustment cylinder piston clevis 031, and these are welded or mounted on top of an inner rotatable ring 013 of the pivotable bell mouth assembly 010. The rod end of the top adjustment cylinders 030 are connected to the top adjustment cylinder rod connection 032, which is a welded or mounted point on the outer surface of the bell mouth body 011. The top angle adjustment "a" is achieved
25 by extending or retracting the top adjustment cylinders 030. The azimuth angle limit stoppers 043 on top of the inner rotatable ring 013 can limit the maximum adjustable azimuth angle of the system. The azimuth adjustment cylinder 020 is used to adjust the azimuth angle, however, if the angle become too large, the cylinder 020 will come into contact and clash against the bell mouth body 011,
30 thereby causing damage. To avoid such clash, the azimuth angle limit stoppers 043 stop further angle adjustment before such clash occurs. Sensors, transducers and other known devices can be installed to detect the angle of the

bell mouth body 011. This would provide feedback to the operator regarding the angle of the bell mouth body 011. The angle of the bell mouth body 011 can be securely locked once the adjustment is completed so that the riser tension can achieve a desired value and the riser can be safely pulled in and locked. Also, the angle of the bell mouth body 011 can be adjusted and locked in without a riser connected, for maintenance purposes or for the replacement of risers. The azimuth adjustment cylinder 020, the top adjustment cylinder 030, azimuth locking cylinder 040 and top locking cylinder 050 can be replaced by other mechanical, hydraulic or electrical actuators by using devices such as a motor drive rack and pinion or worm gear box. These actuators can be controlled remotely by the operator and allow the azimuth and top angle of the bell mouth to be adjusted and locked to fit the riser line, reducing the involvement or need for external assistance, like a diver. Depending on application, data/information on the angle of the bell mouth body 011 for installation of different riser lines can be stored in a database and the actuators can be programmed to adjust the angle of the bell mouth body 011 automatically based on such data/information. Where appropriate, visual indications such as markings can be made on the bell mouth assembly 010 to assist in confirming the desired angles of the bell mouth body 010 and/or visual devices such as a cameras may be suitably used to remotely view and check on the angle of the bell mouth body 011. If required, the orientation of the bell mouth can be adjusted with a riser line and after the orientation is determined, the riser line can be installed, provided all parameters are within the safety limit.

By way of example, Figure 6 shows an embodiment with a pivotable bell mouth assembly 010 with a corresponding exploded isometric view in Figure 7. The bell mouth body 011 is pivotable along the center of its main pins 016. The main pins 016 are mounted on bearing interfacings 017 of the inner rotatable ring 013. The bearing interfacings 012 are detachable and can be fastened to the bear interfacing 017 using bolts 015 so that the main pins 016 on the bell mouth body 011 can be secured within, ensuring that the bell mouth body 011 is able

to pivot, and if required, restrict the degree of freedom to this pivoting. An anti-wearing bushing 014 can be fit in between the main pin 016, bearing interfacing 017 and detachable bearing interfacing 012. Depending on application, the anti-wearing brushing 014 can be a maintenance free type or a normal anti-wearing
5 brushing used with pipe connections for lubrication. Maintenance free parts are preferable. The top wearing plates 006 are fastened on top of detachable bearing interfacing to prevent wearing in between the pivotable bell mouth assembly 010 and locking cover 007. The top locking cylinder 050 can be mounted on a mounting plate 053 which is fixed on the inner rotatable ring 013.

- 10 An embodiment of the bell mouth body is shown in Figure 8. The top locking plate 052, main pins 016 and the top adjustment cylinder rod connection 032 are fixed on the bell mouth body 011, and these are aligned properly before they can be assembled.

A further example shows an embodiment with a steel catenary riser connected
15 in Figures 9A and 9B, where the bell mouth body 011 accommodates the riser line. The azimuth angle "b" and top angle "a" of the bell mouth body 011 are set and locked so that the riser pull in and connection can be smoothly carried out. The clamp 060 is used to lock the steel catenary riser flexible joint 020 to the bell mouth body 011. The motion of the hull can then be compensated by the
20 flexible joint 020.

The embodiments described allow a flexible riser or a steel catenary riser to pass through and be hung from the bell mouth before fluidly coupling the riser to a flowline to side or turret of an FPSO or production vessel.

The various embodiments can be used onboard FPSO, Floating Storage and
25 Offloading vessel (FSO) or other production platforms, and can be used across various industries that transport gas or liquids riser lines.

The above is a description of various embodiments of a bell mouth apparatus for connecting with a riser line in accordance with this invention. It is envisioned that those skilled in the art can and will design an alternative embodiment of
30 this invention that infringe on this invention as set forth in the following claims.

CLAIMS

1. An apparatus for connecting with a riser line, the apparatus comprising a bell mouth having a cross section that allows the riser line to pass through, wherein the orientation of the bell mouth is adjustable by at least one actuator to accommodate the riser line.
2. The apparatus of claim 1, wherein the actuator is operable to actuate the bell mouth to adjust the azimuth angle of the bell mouth to accommodate the riser line.
3. The apparatus of claim 1, wherein the actuator is operable to actuate the bell mouth to adjust the top angle of the bell mouth to accommodate the riser line.
4. The apparatus of claim 1, wherein the actuator is locally/remotely controlled.
5. The apparatus of claim 1, further comprising a plurality of actuators for actuating the bell mouth.
6. The apparatus of claim 5, wherein at least one actuator is operable to actuate the bell mouth to adjust the azimuth angle to accommodate the riser line, and at least one actuator is operable to actuate the bell mouth to adjust the top angle to accommodate the riser line.
7. The apparatus of any one of the preceding claims, further comprising a locking mechanism for locking the bell mouth in position.
8. The apparatus of claim 7, further comprising a first locking mechanism for locking the azimuth angle of the bell mouth and a second locking mechanism for locking the top angle of the bell mouth.
9. The apparatus of claim 7, further comprising a bell mouth support base and a locking cover operable to secure the bell mouth to the bell mouth support base.
10. The apparatus of claim 9, wherein the locking mechanism is mountable on the locking cover.
11. The apparatus of any one of the preceding claims, further comprising a clamp for preventing any movement of the riser line.