

CHAIN STOPPER ASSEMBLY WITH LOAD CELL

TECHNICAL FIELD

5

The present invention relates broadly to a chain stopper assembly for a turret mooring system configured for real-time measuring of the tension in a mooring chain, a method for real-time measuring of the tension in the mooring chain, and a method for *in situ* changing of the load cell in the chain stopper assembly.

10

BACKGROUND

In recent years, the use of floating facilities has become prevalent in the offshore oil and gas industry for the extraction and production of oil and gas from offshore fields. Facilities such as the floating, production, storage and offloading (FPSO) unit or the floating, storage and offloading (FSO) unit are typically floating platforms converted from oil tankers, or in some cases vessels or barges specifically designed and built for the purpose.

20

Generally, these floating platforms comprise of mooring systems which enable them to be fixed to the seabed. One such mooring system is the Turret Mooring system. In a typical turret mooring system, a turret in the form of a vertical cylindrical shaft is fitted through a moonpool within the floating platform. The flange on top end of the vertical cylindrical shaft is in turn mounted on a thrust bearing system which is fixed on the deck of the floating platform. On the other end of the cylindrical turret shaft, a plurality of catenary mooring lines extends out from the bottom of the shaft and anchored it to the seabed. These mooring lines are arranged in such a way that the turret becomes a geostatic turret, where it is fixed to a certain position with respect to the seabed. At the same time, the thrust bearing system connecting the turret to the deck of the floating platform would allow the floating platform to weathervane in response to the prevailing weather conditions, i.e. to rotate or swivel freely about the geostatic turret.

30

In such a mooring system, other than the mooring anchor, the mooring lines, cables or chains play pivotal roles in ensuring that the mooring system has sufficient holding power to keep the mooring turret and in turn the entire floating platform in a fixed position with respect to the seabed. Although the weathervane ability of the floating platform would reduce the impact of the environmental forces on the floating platform, external forces such as roll or pitch motion of the ship with respect to the waves, tidal current acting on the underwater hull of the floating platform, or wind forces acting on the above water structure of the floating platform may still exert a significant force on the floating platform which may be translated to tension acting on these mooring lines, cables or chains, exerting a pulling force on them. The mooring lines, cables or chains in such a mooring system, which are subjected to prolonged exposure of these environmental conditions, would be exposed to cyclical tension loading and would naturally suffer wear and tear. The degradation in the efficacy of the mooring system, especially in the mooring lines, cables or chains, may inadvertently degrade the holding power of the mooring system and thus affect the ability of the mooring turret to be anchored to a fix position on the seabed. In an extreme scenario, the mooring lines, cables or chains may suffer fatigue failure and cause a breakage in one or more of the mooring lines. This may lead to serious consequences where the oil and gas production or extraction risers, connected from the wellhead on the seabed to the turret, may rupture due to the drift in position of the floating platform as a result of the lost of mooring lines, cables or chains.

SUMMARY

According to the first aspect of the present invention, there is provided a chain stopper assembly configured for real-time measuring of the tension in a mooring chain, the chain stopper assembly comprising a chain stopper body; a mounting bracket for supporting the chain stopper body from opposing sides of the chain stopper body via respective saddle blocks coupling the chain stopper body to the mounting bracket; and at least one load cell securing at least one of the saddle blocks to the mounting bracket, for measuring the load between the saddle block and the mounting plate as a measure of the tension in the mooring chain.

The load cell may be received in respective bores on the saddle block and the mounting bracket, such that movement of the saddle block relative to the mounting bracket exerts the load on the load cell.

- 5 The diameter of the bore on the saddle block may be larger than the diameter of the load cell.

The chain stopper body may be supported by the mounting bracket via a shaft and bearing configuration.

10

Each saddle block may support a bearing housing.

The saddle block secured by the load cell may further comprise of a pad eye for receiving a winched rope for facilitating exchange of the load cell.

15

The pad eye may be disposed such that, under application of the winched rope, the saddle block is pivotable to release a load on the load cell for removal of the load cell.

20

According to a second aspect of the present invention, there is provided a method for real-time measuring of the tension in a mooring chain; the method comprising the steps of providing a chain stopper body; providing a mounting bracket for supporting the chain stopper body from opposing sides of the chain stopper body via respective saddle blocks coupling the chain stopper body to the mounting bracket; and providing at least one load cell securing at least one of the saddle blocks to the mounting bracket, for measuring the load between the saddle block and the mounting plate as a measure of the tension in the mooring chain.

25

The method may further comprise the steps of providing a pad eye on the saddle block secured by the load cell for receiving a winched rope for facilitating exchange of the load cell; and application of the winched rope to pivot the saddle block to release a load on the load cell for removal of the load cell.

30

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figure 1(a) is a schematic plan view diagram of the chain stopper assembly according to an example embodiment.

Figure 1(b) is a schematic longitudinal cross sectional diagram of the chain stopper assembly of Figure 1(a).

Figure 1(c) is a schematic side view diagram of one side of the chain stopper assembly of Figure 1(a).

Figure 1(d) is a schematic side view diagram of the other side of the chain stopper assembly of Figure 1(a).

Figure 2(a) is a schematic plan view diagram of the bearing saddle block according to an example embodiment.

Figure 2(b) is a schematic side view diagram of the bearing saddle block of Figure 2(a).

Figure 3 shows a flow chart illustrating a method for real-time measuring of the tension in a mooring chain according to an example embodiment.

DETAILED DESCRIPTION

The inventors have recognized the severe consequences of fatigue failure in the mooring lines, cables or chains of a turret mooring system in a floating platform for oil and gas extraction or production. However, the inventors have also noted that the problem of breakages of mooring lines, cables or chains is not unique to the mooring system of the floating platforms used in offshore oil and gas industry.

Breakages of mooring lines, cables or chains, as well as anchoring lines, cables or chains are common occurrences in the maritime community. Therefore, embodiments of the present invention seek to provide a real-time measuring system for measuring the tension of the mooring or anchoring lines, cables or chains, which
5 may be used in the floating platforms of the offshore oil and gas industry, as well as in any other maritime platform, such as vessels, floating piers or navigation aids, which utilizes similar mooring or anchoring systems.

Embodiments seek to provide a real-time load measuring system by
10 incorporating a load cell into the chain stopper assembly of the mooring or anchoring system to provide real-time information feedback on the tension in the mooring or anchoring lines, cables or chains. At the same time, embodiments also seek to provide means for *in-situ* changing of the load cell in the event that the load cell malfunctions.

Figure 1(a) is a schematic diagram illustrating the plan view of a preferred embodiment of the chain stopper assembly. The chain stopper assembly 100 comprises of a rectangular cuboid shaped chain stopper body 102 connected to a cylindrical tube shaped hawse pipe 104 in such a way that one of the annular
20 surfaces of the cylindrical tube shaped hawse pipe 104 is affixed on one of the surfaces of the chain stopper body 102. In other embodiments, the hawse pipe 104 may be in the shape of a square tube, a rectangular tube or an oval tube instead of a cylindrical tube. The interior of the chain stopper body 102 is hollow and a hole runs from the opening on the surface of the chain stopper body 102, which is
25 opposite to the surface where the hawse pipe 104 is affixed, all the way through to the surface where the hawse pipe 104 is adjoined to the chain stopper body 102. This through-hole marries up with the tunnel of the cylindrical tube shaped hawse pipe 104 forming a conduit for the mooring chain 106 to go through the chain stopper assembly 100 from one end of the chain stopper body 102 to the other end
30 of the hawse pipe 104.

Figure 1(b) is a longitudinal cross-sectional view of the preferred embodiment of the chain stopper assembly. On the top side of the chain stopper body 102, a pawl 108 is connected to the chain stopper body 102 by means of a pin joint 110.

The pin joint 110 allows the pawl 108 to pivot about the pin joint 110 such that the pawl 108 is able to lower or raise at the opening of the chain stopper body 102 where the mooring chain 106 enters. This lowering and raising motion of the pawl 108 can close or open the opening of the chain stopper body 102 where the mooring chain 106 enters. During a mooring operation, when the desired length of the mooring chain 106 is paid out, the chain stopper assembly 100 is required to stop the mooring chain 106 from paying out further and hold on to the mooring chain 106 at the required length. This is achieved by lowering the pawl 108 such that it closes the opening of the chain stopper body 102 where the mooring chain 106 enters. By doing so, a horizontal link 109 of the mooring chain 106 will rest on the claws of the pawl 108 thereby stopping the pay out of mooring chain 106. With the horizontal link 109 abutting to the pawl 108, any tension load on the mooring chain 106 is transferred to the chain stopper body 102 through the interaction between the horizontal link 109 of the mooring chain 106 and the claws of the pawl 108.

As shown in Figure 1(a), on the remaining two opposing side surfaces of the chain stopper body 102 which is adjacent to the surface where the hawse pipe 104 is connected, a shaft 112, 114 is affixed on each of the opposing side surfaces such that the axis of each shaft 112, 114 coincides. Each of the shafts 112, 114 is fitted through the bore of the inner ring of a rolling bearing 116, 118 such that the chain stopper assembly 100 is rotatable about the common axis of the shafts 112, 114. This rotational motion may allow the chain stopper assembly 100 to rotate and response in relation to changes in tension of the mooring chains 106.

Each of these rolling bearings 116, 118 is mounted on a bearing housing 120, 122 which has a rounded exterior surface. Each of the bearing housing 120, 122 in turn sits in a bearing saddle block 124, 126 such that the rounded exterior surface of each bearing housing 120, 122 fits into the curved groove surface of each respective bearing saddle block 124, 126. On the end of each bearing housing 120, 122 opposite to the bearing saddle block 124, 126, a locking device 128, 130 is installed such that each bearing housing 120, 122 is maintained in between the respective bearing saddle block 124, 126 and locking device 128, 130. In this arrangement, the chain stopper body 102 will exert a load on the bearing saddle

blocks 124, 126 as the tension in the mooring chain 106 acts on the chain stopper body 102.

Figure 1(c) and 1(d) are schematic diagrams illustrating the respective side views of a preferred embodiment of the chain stopper assembly. As shown in Figure 1(c), each locking device 128, 130 comprises of a quadrant circular arc shaped mounting plate 131 and two rectangular locking plates 133, 135. The two rectangular locking plates 133, 135 are welded on the quadrant circular arc shaped mounting plate 131 such that they are perpendicular to the plane of the quadrant circular arc shaped mounting plate 131, and are aligned in the radial direction of the quadrant circular arc. This quadrant circular arc shaped plate 131 is secured by means of bolts and nuts to the mounting bracket 132, 134.

As shown in Figure 1(c) and Figure 1(d), the bearing saddle block 124 and the bearing saddle block 126 are different. The bearing saddle block 126 is designed to incorporate a load cell such that the tension force of the mooring chain 106, which is indirectly transferred to the bearing saddle blocks 124, 126 via the chain stopper body 102, can be measured whereas the bearing saddle block 124 is only a standard bearing saddle block supporting the bearing housing 120. The standard bearing saddle block 124 is semi-circular in shape and is welded onto the mounting bracket 132 as shown in Figure 1(d).

Figure 2(a) and 2(b) are the schematic diagrams showing the plan view and side view of the bearing saddle block 126. The bearing saddle block 126 has a semi-circular saddle section 202, similar to the standard saddle block 124. However, on the exterior of the semi-circular saddle section 202, there are two parallel flange-like protrusions 204, 212. On each of the flange-like protrusion 204, 212, there is two circular bores 206, 208 with their centre coinciding with the corresponding circular bores on the parallel flange-like protrusion 204, 212. As can be seen in Figure 1(a) and Figure 1(c), the bearing saddle block 126 is fitted onto the mounting bracket 134 by slotting the parallel flange-like protrusion onto the mounting bracket 134. A solid securing pin 136 and a pin-type load cell 138 are then fitted through the respective circular bore 206, 208 to secure the bearing saddle block 126 to the mounting bracket 134.

In the described embodiment, the tension load on the mooring chain 106 is transferred to the chain stopper body 102, and then passed on to the bearing saddle blocks 124, 126. The load acting on the bearing saddle block 126 may be measured and recorded by the pin-type load cell 138, which is used for securing the bearing saddle block 126 to the mounting bracket 134. However, the pin-type load cell 138 has to be calibrated, taking into account the load distribution from the chain stopper body 102 to the pin-type load cell 138, the securing pin 136 and the standard bearing saddle block 124, so that the readings from the pin-type load cell 138 can be taken as a measure of the actual tension in the mooring chain 106.

In this embodiment, the bearing saddle block 126 has a pad eye feature 210 at the end of the bearing saddle section 202 on the side closest to the bore 208 where the pin-type load cell 138 is inserted. The bore 208 is also slightly larger than the diameter of the pin-type load cell 138. In addition, there is a slight clearance between the locking plates 133, 135 and the bearing housing 120, 122. The combination of these three features permits the *in situ* changing of the pin-type load cell 138 through the following steps when the pin-type load cell 138 malfunctions. Firstly, a wire rope is fastened to the pad eye feature on the bearing saddle block 126. This wire rope is then connected to a heavy duty winch which may be mounted on the upper decks of the mooring turret shaft. Secondly, the winch pulls the wire rope to release the tension on the pin-type load cell 138. The release of the tension can be achieved because the enlarged bore 208, which is slightly larger than the diameter of the pin-type load cell 138, and the clearance between the locking plates 133, 135 and the bearing housing 120, 122 allow the bearing saddle block 126 to pivot slightly about the solid securing pin 136 when the wire rope pulls the bearing saddle block 126 by the pad eye feature 210. Thirdly, when the tension is released from the pin-type load cell 138, the pin-type load cell 138 is removed and replaced. Lastly, after the new pin-type load cell 138 is inserted, the winch lowers the wire rope until the bearing saddle block 126 is again supported by the new pin-type load cell 138. The pad eye feature 210, the slightly enlarged bore 208, and the clearance between the locking plates 133, 135 and the bearing housing 120, 122 in this embodiment have provided a means for *in situ* removing and inserting of the pin-

type load cell 138 without the need to dismantle the chain stopper assembly 100 or adjust the mooring chain 106 in the chain stopper assembly 100.

5 The pin-type load cell 138 used in this embodiment can be an electric load cell. The electric load cell will be waterproof and the electric load cell's cable can be connected to the wiring on the turret shaft via commercially available wet mate-able underwater electric connector. A readout connected to the wiring of the electric load cell can be provided either on the turret shaft or in the central control room of a FPSO or FSO such that real-time measurements of the tension in the mooring chain
10 106 can be monitored by the operators on duty.

In another embodiment, the bearing saddle 126 has pad eye features 210 on both ends of the bearing saddle section 202. Both the bores 206 and 208 are also slightly larger than the diameter of the pin-type load cell 138. Pin-type load cells 138
15 are used in both the enlarged bores 206 and 208 for securing. In this embodiment, the chain stopper assembly is able to measure more accurately the tension experienced by the mooring chain with the two pin-type load cells 138. In addition, the pad eye feature 210 on each end can allow the changing of the pin-type load cell using the method described above. Accordingly, when a pin-type load cell 138
20 malfunctions, a wire rope is fastened to the pad eye feature 210 on the side closest to the malfunctioned pin-type load cell 138. The winch then pulls the wire rope and pivots the bearing saddle block 126 about the other pin-type load cell 138. This will release the tension on the malfunctioned pin-type load cell 138. When the tension is released, the malfunctioned pin-type load cell 138 is replaced. Thereafter, the winch
25 lowers the bearing saddle block 126 such that the bearing saddle block 126 rests again on both the pin-type load cells 138 in bore 206 and bore 208.

In a further embodiment, both the bearing saddle blocks are of the same type such that both have the flange-like protrusions 204, 212 on the exterior of the semi-
30 circular section 202. On each of the flange-like protrusion 204, 212, there is two circular bores 206, 208 with their centre coinciding with the corresponding circular bores on the parallel flange-like protrusion 204, 212. Both the bearing saddle blocks 126 are fitted onto the mounting bracket 132, 134 by slotting the parallel flange-like protrusions 204, 212 onto the mounting bracket 132 and 134. A solid securing pin

136 and a pin-type load cell 138 are then fitted through the respective circular bore 206, 208 to secure the respective bearing saddle blocks 126 to the mounting brackets 132, 134. This embodiment may allow the load acting on both sides of the chain stopper assembly 100 to be measured and thus can provide a more accurate measurement of the tension loading in the mooring chain 106.

In another embodiment, both the bearing saddle blocks are of the same type such that both have the flange-like protrusions 204, 212 on the exterior of the semi-circular section 202. Both the bores 206 and 208 on each of the flange-like protrusion 204, 212 on each of the bearing saddle block 126 are slotted with the pin-type load cell 138 such that the bearing saddle blocks 126 are secured to the mounting bracket 132, 134 by four pin-type load cells 138. In this embodiment, the tension load acting on the chain stopper assembly 100 may be measured more accurately because the combine readings from the four pin-type load cells 138 is equivalent to the actual tension in the mooring chain, without the need for further force distribution analysis.

Figure 3 shows a flow chart 300 illustrating a method for real-time measuring of the tension in a mooring chain according to an example embodiment. At step 302, a chain stopper body is provided. At step 304, a mounting bracket for supporting the chain stopper body from opposing sides of the chain stopper body via respective saddle blocks coupling the chain stopper body to the mounting bracket is provided. At step 306, at least one load cell securing at least one of the saddle blocks to the mounting bracket is provided, for measuring the load between the saddle block and the mounting plate as a measure of the tension in the mooring chain.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A chain stopper assembly configured for real-time measuring of the tension in a mooring chain, the chain stopper assembly comprising:

5 a chain stopper body;

a mounting bracket for supporting the chain stopper body from opposing sides of the chain stopper body via respective saddle blocks coupling the chain stopper body to the mounting bracket; and

10 at least one load cell securing at least one of the saddle blocks to the mounting bracket, for measuring a load between the saddle block and the mounting plate as a measure of the tension in the mooring chain.

2. The assembly as claim in claim 1, wherein the load cell is received in respective bores on the saddle block and the mounting bracket, such that movement
15 of the saddle block relative to the mounting bracket exerts the load on the load cell.

3. The assembly as claim in claim 2, wherein a diameter of the bore on the saddle block, is larger than a diameter of the load cell.

20 4. The assembly as claimed in any one of the preceding claims, wherein the chain stopper body is supported by the mounting bracket via a shaft and bearing configuration.

5. The assembly as claimed in claim 4, wherein each saddle block
25 supports a bearing housing.

6. The assembly as claimed in any one of the preceding claims, wherein the saddle block secured by the load cell further comprises a pad eye for receiving a winched rope for facilitating exchange of the load cell.
30

7. The assembly as claimed in claim 6, wherein the pad eye is disposed such that, under application of the winched rope, the saddle block is pivotable to release a load on the load cell for removal of the load cell.

8. A method for real-time measuring of the tension in a mooring chain; the method comprising the steps of:

providing a chain stopper body;

5 providing a mounting bracket for supporting the chain stopper body from opposing sides of the chain stopper body via respective saddle blocks coupling the chain stopper body to the mounting bracket; and

providing at least one load cell securing at least one of the saddle blocks to the mounting bracket, for measuring the load between the saddle block and the mounting plate as a measure of the tension in the mooring chain.

10

9. The method as claimed in claim 8, further comprising:

providing a pad eye on the saddle block secured by the load cell for receiving a winched rope for facilitating exchange of the load cell; and

15 application of the winched rope to pivot the saddle block to release a load on the load cell for removal of the load cell.