

Unmanned vessel for offshore hydrocarbon production, storage and offloading

Technical field

5 The present invention relates to a vessel for offshore hydrocarbon production, storage and offloading. Also, the invention relates to a method for manufacturing such a vessel.

Background

10 While in offshore industry unmanned wellhead facilities are very well established and have a 40 year track record, minimum manned facilities where an element of processing (separation, dehydration or compression) takes place offshore are far less so. In particular, the operation of floating facilities such as floating hydrocarbon production, storage and offloading platforms or vessels still requires large crews consisting of for example,
15 production personnel, maintenance and support staff. Typically, the vessel or platform, hereafter FPSO, is located remotely from shore and the crew stays on-board the FPSO for relatively long time. Consequently, a relatively large portion of the FPSO is used for facilities supporting the crew.

 Also, in the prior art the processing equipment is arranged and laid out in a manner
20 that operations can be carried out by humans, which may not be an optimal layout for the hydrocarbon processing.

 It is an objective of the invention to overcome or mitigate the disadvantages from the prior art.

Summary of the invention

 The objective is achieved by an offshore hydrocarbon production storage and offloading vessel to be located on a body of water, comprising a vessel-type hull, hydrocarbons processing equipment and a mooring system,
 the vessel comprising a topsides structure holding the hydrocarbon processing equipment
30 that is lengthwise extending, from aft to bow, arranged into at least three sections, with non-hydrocarbon processing modules being installed in a first section, low pressure / low explosion risk hydrocarbon processing modules in a second section and high pressure hydrocarbon gas and toxic compounds processing modules in a third section, the second section being located between the first and third sections, wherein

the vessel is provided with one or more central handling and/or maintenance structures;
a track is provided at a level above or at a top level of the sections;
the track being configured for holding the one or more central handling and/or maintenance
structures and allowing travel of said structures on said track.

5 According to an embodiment, a vessel as described above is provided in which the
track comprises rails and/or a plated structure on which the one or more structures can
travel.

 According to an embodiment, a vessel as described above is provided in which the
track extends substantially along a length of the vessel.

10 According to an embodiment, a vessel as described above is provided in which the
track is arranged along either a sidewall of the hull or a centerline of the vessel.

 According to an embodiment, a vessel as described above is provided in which the
central handling and/or maintenance structure is a maintenance structure equipped with a
large capacity lifting equipment and capability for deployment of one or more robotic devices
15 on the topsides structure.

 According to an embodiment, a vessel as described above is provided in which the
central handling and/or maintenance structure is a maintenance structure is equipped with
one or more robotic arms on which a robotic device is mounted.

 According to an embodiment, a vessel as described above is provided in which the
20 topsides structure comprises one process deck or a plurality of process decks positioned at
different levels above each other, and optionally on each process deck between and along
the respective processing modules service aisles are provided, in which each service aisle is
configured for access by a robotic device.

 According to an embodiment, a vessel as described above is provided in which each
25 process deck comprises a garage for holding the robotic device, and optionally the garage is
provided with an elevator for allowing movement of the robotic device between the different
levels of the process decks.

 The garage provides a dock for the robotic equipment when not in use and to shelter
the robotic equipment from the offshore environment. In addition, the garage has space for
30 storing tools and equipment spares used by the robotic equipment. Also, the garage can be
provided with a power supply to which the robotic equipment can connect for restoring its
energy level.

 The elevator provides that robotic equipment can be transferred from one process
deck level to another. In this manner equipment can be shared between various deck levels

if needed. Also, the elevator may be controllable by the robotic equipment, in such a way that the robotic equipment can autonomously move between various deck levels.

According to an embodiment, a vessel as described above is provided in which on at least one process deck high energy rotating equipment comprising at least power generators and compressors, is arranged on outside of the respective processing module adjacent to the hull sidewalls, the high energy equipment being configured with couplers for detachably coupling with other components of the processing modules and comprising a connector on the equipment for a crane.

This arrangement allows relatively easy access to a type of equipment that typically requires relatively frequent maintenance and/or replacement which may exceed the servicing capabilities of robotic equipment. By providing on the equipment a connector for a crane, the equipment can be removed or replaced by a crane on the vessel but alternatively also by a crane on a support vessel.

According to an embodiment, a vessel as described above is provided in which on the at least one process deck static equipment is arranged on the inside of the processing module facing away from the hull sidewalls. This equipment typically requires less maintenance or replacement and can thus be located at positions more remote from a support vessel. Also, this type of equipment may be serviced completely by robotic equipment.

According to an embodiment, a vessel as described above is provided in which the at least one process deck comprises a central corridor extending lengthwise and the track is arranged above the central corridor.

According to an embodiment, a vessel as described above is provided in which the central corridor comprises at least one service aisle for robotic device(s) deployed from the one or more central handling and/or maintenance structure.

According to an embodiment, a vessel as described above is provided in which the hull is provided with a central vertical passage for arranging and accommodating risers for connection between a subsea hydrocarbons well at the production location and the hydrocarbons processing equipment, wherein optionally the third section is located adjacent to the bow and above the central passage.

The FPSO according to this embodiment is configured for spread mooring, so that it will have a fixed orientation at the location above the offshore hydrocarbon field. Still a central passage inside the hull is provided to allow risers, lines, etc. to enter the vessel. Such arrangement of the risers allows to remove riser balconies to free up space for ship-to-ship access along the sides of the hull. This creates flexibility so that a support vessel could

freely approach the FPSO from either side for campaign by maintenance or other necessary interventions. Moreover, the arrangement of process equipment in three different zones with varying operational risk allows that the hydrocarbons production process becomes safer as the process flow substantially follows the zone arrangement.

5 According to an embodiment, the vessel further comprises a flare tower, wherein the flare tower is located at the aft, adjacent to the first section of the processing modules, and/or comprises an auxiliary equipment module comprising at least a metering unit, at least one auxiliary power generator, and pump units, wherein the auxiliary equipment module is located between the aft and the first section of the processing modules, and/or further
10 comprises offloading equipment, preferably located at the aft, with a floating hose for coupling to a shuttle tanker, and wherein the offloading equipment comprises a docking station for docking the free end of the floating hose when not coupled to the shuttle tanker.

 By positioning the flare tower between the aft and the first section the flare is isolated from the second and third sections of process equipment which have relatively higher risk of
15 explosions when exposed to fire. According to prior art, the auxiliary equipment would be placed inside the hull. In this embodiment, by placing the equipment on deck, relatively more hull volume is available for fluid storage for liquid chemicals used in the hydrocarbon production process.

 Depending on requirements, equipment can be stacked allowing to arrange
20 equipment of comparable risk within the same section.

 In some embodiments, on each process deck between and along the respective processing modules service aisles are provided, in which each service aisle is configured for access by robotic equipment. The presence of service aisles between and along process modules allows to have maintenance procedures carried out by robotic equipment that is
25 designed to interact with the process modules. Depending on the required maintenance the robotic equipment is provided with tools specific for carrying out the maintenance.

 According to an embodiment, a vessel as described above is provided in which at least one process deck comprises a central corridor extending lengthwise and containing an area for one or more interconnecting pipe racks between various equipment within the
30 processing module on said process deck.

 According to an embodiment, a vessel as described above is provided in which the central corridor comprises at least one service aisle for robotic equipment.

 In some embodiments, a vessel as described above is provided which further comprises offloading equipment, preferably located at the aft, with a floating hose for

coupling to a shuttle tanker, and wherein the offloading equipment comprises a docking station for docking the free end of the floating hose when not coupled to the shuttle tanker.

In some embodiments, a vessel as described above is provided in which the hull is configured for allowing access by a walk-to-work vessel at each hull sidewall by means of a gangway, preferably providing a landing porch extending outboard.

Brief description of drawings

The invention will be explained in more detail below with reference to drawings in which illustrative embodiments thereof are shown. The drawings are intended exclusively for illustrative purposes. The scope of the invention is only limited by the definitions presented in the appended claims.

Figure 1 shows a perspective view of a vessel according to an embodiment;
Figure 2 shows a perspective view of a hull portion of the vessel of Figure 1;
Figure 3A, 3B show a perspective view and a top view, respectively, of a processing modules area on the vessel, and
Figure 4 shows a cross-sectional view of a processing modules area on the vessel.

Detailed description of embodiments

Figure 1 shows a perspective view of a vessel 100 according to an embodiment.
According to an embodiment of the invention, an offshore hydrocarbon production storage and offloading vessel 100 is provided for mooring at a location at sea above an oil field and/or gas field. The vessel is moored at the location by spread mooring using mooring lines 110 that are attached to seabed anchors (or piles), not shown here. Alternatively, the vessel 100 may be configured with a turret mooring system.

On the vessel 100 the hydrocarbon processing equipment is located on a topsides structure on a process deck that comprises one or more process deck levels. The process deck comprises at least three sections 20, 21, 22, 23.

In a first section 20 non-hydrocarbon processing modules are installed that are associated with processes not involved in processing hydrocarbons.

In a second section 21 low pressure / low explosion risk hydrocarbon processing modules are installed that are associated with processing hydrocarbons from the feed in processes run at relatively low pressure and/or with low explosion risk.

Processes involving high pressure hydrocarbon gas and toxic compounds are run in a third section 22 of the hydrocarbon processing modules.

The first, second and third sections are arranged lengthwise on the vessel. The second section 21 with intermediate explosion risk is located between the first 20 and third sections 22.

5 In an embodiment, the third high risk section 22 is located adjacent and/or above the central passage. The low risk first section 21 is located adjacent to the aft of the vessel.

Additional sections 23 may be installed in the topsides structure either on the side of the third section or the first section depending on the risk involved in the processes run in the additional section.

10 For example, the additional section 23 may comprise equipment for entry of high pressure hydrocarbons. As shown in Figure 1, the additional section 23 is located adjacent at the third section 22

According to an embodiment, separations in the topsides structure are provided between sections for protection of the sections from each other.

The topsides structure may comprise one or more cranes (26, see Figure 2).

15 According to an embodiment, a track 70 is provided at a level above or at the top level of the sections 20, 21, 22, 23, which is configured for travel of one or more central handling and/or maintenance structures (not shown). The track can comprise rails and/or a plated structure on which the one or more central handling and/or maintenance structures can be moved.

20 In a preferred embodiment the track 70 extends substantially along the length of the vessel. The track can be arranged for example along a sidewall of the hull or along the centerline of the vessel, depending on the layout of the topsides structure of the sections.

In this manner the moveable central handling and/or maintenance structures can be positioned at any location above the sections. The functionalities of the one or more central
25 handling and/or maintenance structures will be explained in more detail with reference to Figures 2 - 4.

Figure 2 shows a longitudinal cross-section of the vessel of Figure 1.

On the track 70, the one or more central handling and/or maintenance structures are positioned. In an exemplary embodiment two central handling and/or maintenance structures
30 71, 72 are provided. In this example, a first structure 71 is a maintenance structure equipped with a large capacity lifting equipment and capability for deployment of at least one robotic device. This central handling and/or maintenance structure 71 is configured to deploy a robot 73 at a position on the hull, for example at a position in one of the sections, where the robot can perform some operation such as maintenance.

Further, a second structure 72 is arranged at a different position on the track. The second central handling and/or maintenance structure 72 is equipped with one or more robotic arms 74. Accordingly, the second central handling and/or maintenance structure 72 is configured to perform local operations in one or more of the sections by means of the robotic arm(s) 74. Similar to the first structure 71 the second structure 72 is moveable to a selected position on the track where the operation by the robotic arm(s) is required.

The robot(s) and/or robotic arm(s) are configured to operate either autonomous or by remote control through wired (electrical or optical) connection or through wireless connection. In an embodiment a wireless connection is provided by a satellite link.

According to an embodiment, a flare tower 28 including flare drums are located at the aft 25 of the vessel remote from the second and third sections 21, 22, 23 with relatively moderate and higher explosion risks.

Inside the hull, the vessel comprises storage tanks 30, 31, 32 for hydrocarbons and by-products.

According to an embodiment, an offloading system 33, 34 is arranged at the aft of the vessel. The offloading system comprises a pumping system 33 and at least a 33 floating hose 34 which is connected at one end to an offloading point on the vessel. The other free end which is configured to float on the water surface is arranged for connection to a shuttle tanker during the offloading process. When not in use, the free end of the floating hose can be connected to the vessel near the water line. The use of a floating hose that is permanently floating facilitates a relatively easy connection procedure with the tanker and reduces the duration of the offloading process.

Typically, the floating hose may have a length of at least 250 meters to allow a safe distance between the vessel and the tanker.

Optionally, the hull 10 of the vessel is provided with a central vertical passage 27 through which risers from an oil field and/or gas field enter and are connected to hydrocarbon processing equipment on the vessel for providing treated oil and gas from the field. Also, other connections to subsea equipment such as power lines or communication lines can be arranged to enter the vessel through the central passage. By this alternative arrangement of risers and other lines in the central passage, the arrangement of riser balconies to connect subsea risers on the sidewalls of the hull 10 is not required. By keeping the sidewalls free, support vessels can moor directly to the vessel on each of the sidewalls. Ship-to-ship access would be improved in this optional arrangement. Inside the hull 10 a central passage 27 is arranged that serves as a passage for risers that connect a subsea well 120, 125 with the hydrocarbons processing equipment on-board the vessel. Also, the

central passage 27 can be used as passage for other lines and conduits, such as power and communication lines and water injection lines. The central passage 27 can be a moon pool or can consist of a central section in the hull 10 with one or more pipes penetrating the hull.

Figures 3A, 3B show a perspective view and a top view of a processing modules area
5 40 on the vessel, respectively.

In Figure 3A a topsides structure 20; 21; 22; 23 according to an embodiment is depicted. The topsides structure comprises a plurality of process decks 42, 43, 44 that are located above each other at various levels from the top deck of the hull. On the process decks (hydrocarbons) process equipment 45, 46 is installed as explained above with
10 reference to Figure 1. Depending on the area required for the process equipment the number of levels of the process decks can vary from one to three or more.

In an embodiment, the track 70 is arranged at a side of the topmost deck 42 such that the track extends along the length of the vessel and the central handling and/or maintenance structure(s) 71; 72 can move along the side.

On each level 42, 43, 44 of the process decks, infrastructure 50 is laid out to guide
15 robotic equipment 51, 52 deployed by the first structure 71 to locations on the decks, for example, to service process equipment 45, 46. As shown in Figure 3B, on a process deck there is infrastructure comprising aisles 50 detectable by the robotic equipment 51, 52. Additionally, the infrastructure may comprise a number of (electronic) beacons 53 detectable
20 by the robotic equipment for navigation.

According to an embodiment, the lifting equipment of the first central handling and/or maintenance structure 71 is configured for transport a robot to any level 42, 43, 44 in a process section 20; 21; 22; 23, if the section is provided with vertical pull-up openings 75 on each of the levels.

The infrastructure has a lay-out that enables a robot to position itself to a
25 predetermined location near a process module to carry out a specific maintenance or service on the module.

The robots 51, 52 may be configured with dedicated tools for a specific maintenance task. Alternatively, a robot may be arranged to exchange tools depending on the actual
30 maintenance task to perform.

In case the robot is attached to the robotic arm of the second structure 72, the second central handling and/or maintenance structure 72 may be moved along the track 70 to a position of target equipment where the robotic tool 73 mounted on the robotic arm(s) can work on. The robotic arm is typically configured as a manipulator to position and align
35 the robotic tool with the target equipment.

The topsides structure further comprises one or more garages 54 to store robotic equipment on the various levels of process decks (see Figure 3A). The garages are included in the lay-out on the process decks so that robotic equipment can reach the location of a garage.

5 According to an embodiment, garages on various levels of the process decks are positioned above each other and configured with an elevator to allow robotic equipment to travel from one level to another level of the process deck.

In an alternative embodiment, the garage(s) and elevator(s) are separate units.

10 According to an embodiment, on the process decks one or more garages 54 may be arranged for storing and sheltering robotic equipment not in use. Also, the garages may be used as a storage and exchange for various tools used by the robotic equipment. Preferably, the one or more garage(s) comprise one or more docks for providing energy to the robotic equipment.

15 Figure 4 shows a cross-sectional view of a processing modules area 40 on the vessel 100.

In Figure 4 the topsides structure is shown in transverse direction across the vessel.

In this exemplary embodiment, the topsides structure comprises three levels of process decks 42, 43, 44. A corridor 55 is arranged along the centreline of the vessel 100 that comprises an area for interconnecting pipe-rack 56 and a longitudinal passageway 57 for robotic and transport equipment. On each side of the corridor process equipment 45, 46 is arranged on the process deck levels. The track 70 is arranged above the corridor 55 allowing the one or more moveable central handling and/or maintenance structures 71, 72 to do robotic maintenance on either side of the track. As described above the structure 71 may be configured to deploy a robotic device at any level 42, 43, 44 in a process section.

25 In some embodiments, the track 70 has a width that allows the central handling and/or maintenance structures 71, 72 to pass by each other.

30 According to an embodiment, the process equipment is distributed between the sidewalls and the corridor area in correspondence with the (estimated) requirement for maintenance of the equipment. Process equipment with a higher requirement is arranged in an outer portion 60 of the process deck adjacent to the sidewalls, other equipment is arranged in an inner portion 61, closer to the corridor area. Further, the process equipment in the outer portion is configured for removal by a support vessel using a crane. In this manner, equipment can be removed for maintenance or repair, and replaced by other equipment delivered by the support vessel (not shown). Alternatively or additionally, the crane 26 can be located on the vessel 100.

Process equipment with a higher requirement for maintenance comprises dynamic equipment such as rotating equipment: generators, pumps etc. Equipment with lower requirement for maintenance comprises static equipment such as separators, scrubbers, storage tanks, valve equipment, etc.

5 It will be appreciated that the offshore hydrocarbon production storage and offloading vessel as described above can also be embodied as a circular FPSO type vessel that is configured for spread mooring at a production location and which has a hull that is provided with a central passage for arranging and accommodating risers for connection between a subsea hydrocarbons well at the production location and the hydrocarbons processing
10 equipment.

The circular FPSO is configured with a topsides structure holding the hydrocarbon processing equipment that is segmented into at least three sections, with non-hydrocarbon processing modules being installed in a first section, low pressure / low explosion risk hydrocarbon processing modules in a second section and high pressure hydrocarbon gas
15 and toxic compounds processing modules in a third section. A separation wall can be placed between the sections for shielding.

In a similar manner as described above, the topsides structure comprises one process deck or a plurality of process decks positioned at different levels above each other.

On each process deck between and along the respective processing modules service
20 aisles may be provided, in which each service aisle is configured for access by robotic equipment. Each process deck may comprise a garage for holding the robotic equipment, which may be connected by an elevator to other process decks.

The invention has been described with reference to the preferred embodiment. Obvious modifications and alterations will occur to the skilled person upon reading and
25 understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims.

Claims

1. An offshore hydrocarbon production storage and offloading vessel to be located on a body of water, comprising a vessel-type hull, hydrocarbons processing equipment and a mooring system,
5 the vessel comprising a topsides structure holding the hydrocarbon processing equipment that is lengthwise extending, from aft to bow, arranged into at least three sections, with non-hydrocarbon processing modules being installed in a first section, low pressure / low explosion risk hydrocarbon processing modules in a second section and
10 high pressure hydrocarbon gas and toxic compounds processing modules in a third section, the second section being located between the first and third sections, wherein the vessel is provided with one or more moveable central handling and/or maintenance structures;
a track is provided at a level above or at a top level of the sections,
15 the track being configured for holding the one or more central handling and/or maintenance structures and allowing travel of said structures on said track.
2. The vessel according to claim 1, wherein the track comprises rails and/or a plated structure on which the one or more central handling and/or maintenance structures
20 can travel.
3. The vessel according to claim 1 or 2, wherein the track extends substantially along a length of the vessel.
- 25 4. The vessel according to any one of claims 1 - 3, wherein the track is arranged along either a sidewall of the hull or a centerline of the vessel.
5. The vessel according to any one of the preceding claims, wherein the central handling and/or maintenance structure is a maintenance structure equipped with a
30 large capacity lifting equipment and capability for deployment of one or more robotic devices on the topsides structure.
6. The vessel according to any one of preceding claims 1 - 4, wherein the central handling and/or maintenance structure is a maintenance structure equipped with one

or more robotic arms on which a robotic device is mounted.

7. The vessel according to any one of preceding claims 1 - 6, wherein the topsides structure comprises one process deck or a plurality of process decks positioned at different levels above each other, and optionally on each process deck between and along the respective processing modules service aisles are provided, in which each service aisle is configured for access by a robotic device.
8. The vessel according to claim 7, wherein each process deck comprises a garage for holding the robotic device, and optionally the garage is provided with an elevator for allowing movement of the robotic device between the different levels of the process decks.
9. The vessel according to any one of the preceding claims, wherein on at least one process deck high energy rotating equipment comprising at least power generators and compressors, is arranged on outside of the respective processing module adjacent to the hull sidewalls, the high energy equipment being configured with couplers for detachably coupling with other components of the processing modules and comprising a connector on the equipment for a crane.
10. The vessel according to any one of the preceding claims, wherein on the at least one process deck static equipment is arranged on the inside of the processing module facing away from the hull sidewalls.
11. The vessel according to any one of the preceding claims, wherein the at least one process deck comprises a central corridor extending lengthwise and the track is arranged above the central corridor.
12. The vessel according to claim 11, wherein the central corridor comprises at least one service aisle for robotic device(s) deployed from the one or more central handling and/or maintenance structures.
13. The vessel according to any one of the preceding claims, wherein the hull is provided with a central vertical passage for arranging and accommodating risers for connection between a subsea hydrocarbons well at the production location and the hydrocarbons

processing equipment,
wherein optionally the third section is located adjacent to the bow and above the
central passage.

- 5 14. The vessel according to any one of claims 1 - 13, further comprising a flare tower,
 wherein the flare tower is located at the aft, adjacent to the first section of the
 processing modules, and/or
 comprising an auxiliary equipment module comprising at least a metering unit, at
 least one auxiliary power generator, and pump units, wherein the auxiliary equipment
10 module is located between the aft and the first section of the processing modules,
 and/or
 further comprising offloading equipment, preferably located at the aft, with a floating
 hose for coupling to a shuttle tanker, and wherein the offloading equipment
 comprises a docking station for docking the free end of the floating hose when not
15 coupled to the shuttle tanker.
15. The vessel according to claim 13 or 14, wherein the power cables, control and
 communications cables enter the vessel through the central vertical passage.

20