

(19)



(11)

EP 2 903 889 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
30.11.2016 Bulletin 2016/48

(51) Int Cl.:
B63B 35/44 ^(2006.01) **B63B 21/50** ^(2006.01)
B63J 2/00 ^(2006.01)

(21) Application number: **13765699.7**

(86) International application number:
PCT/EP2013/069281

(22) Date of filing: **17.09.2013**

(87) International publication number:
WO 2014/053314 (10.04.2014 Gazette 2014/15)

(54) **FLOATING OFF-SHORE HYDROCARBON GAS PROCESSING PLANT, METHOD OF DEPLOYING SUCH FLOATING GAS PROCESSING PLANT, AND METHOD OF PRODUCING LIQUEFIED NATURAL**

SCHWIMMENDE OFFSHORE-KOHLLENWASSERSTOFFGASVERARBEITUNGSANLAGE,
VERFAHREN ZUM EINSETZEN SOLCH EINER SCHWIMMENDEN GASVERARBEITUNGSANLAGE
UND VERFAHREN ZUR HERSTELLUNG VON VERFLÜSSIGTEM ERDGAS

USINE DE TRAITEMENT DE GAZ D'HYDROCARBURE FLOTTANTE EN MER, PROCÉDÉ DE
DÉPLOIEMENT DE CETTE USINE DE TRAITEMENT DE GAZ FLOTTANTE ET PROCÉDÉ DE
PRODUCTION DE GAZ NATUREL LIQUÉFIÉ

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **03.10.2012 EP 12187116**

(43) Date of publication of application:
12.08.2015 Bulletin 2015/33

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Description

[0001] The present invention relates to a floating off-shore hydrocarbon gas processing plant and to a method of deploying such floating gas processing plant. In another aspect, the invention relates to a method of producing liquefied natural gas.

[0002] Floating off-shore hydrocarbon gas processing plants are known in various forms, including for example so-called floating production storage and off-loading (FPSO) concepts. Over the past years, various concepts for floating natural gas liquefaction plants have been proposed. US Patent 7,318,387 represents the closest prior art and describes a water intake riser that is used on a vessel on which a plant for liquefying natural gas (a liquefied natural gas plant) is arranged. Such a water intake riser is used on the vessel to provide cooling water to a heat exchanger. The water intake riser is suspended from the hull of the vessel via a riser hanger.

[0003] The riser hanger of US Patent 7,318,387 is of a specially adapted design wherein a piece of hose forms a conduit to convey water from the water intake riser pipe being suspended from the riser hanger to the vessel, while a flexible load transfer element transfers self-weight and dynamic loads of the water intake riser. Furthermore, during deployment of the vessel with the liquefied natural gas plant, the water intake risers have to be deployed by slidably lowering the risers through apertures of guide sleeves, which guide sleeves form part of a riser spacer that is suspended from the vessel to a predetermined depth.

[0004] When deploying the vessel described in US Patent 7,318,387 for use in a location off-shore, the riser spacers and the water intake risers have to be lowered and installed before cooling water can be provided to the heat exchanger. This contributes to the time delay between arrival of the vessel at the deployment site and being able to use the hydrocarbon gas processing plant that is arranged on the vessel.

[0005] In accordance with a first aspect of the present invention, there is provided a floating off-shore hydrocarbon gas processing plant arranged on a floating structure, wherein said floating structure floats on a body of water above a sea bed, wherein the floating structure is anchored to the sea bed via an anchor line being attached to an anchor point on the sea bed, and wherein a water intake hose is provided comprising a distal end projecting away from the floating structure into the body of water and a proximal end that is connected to the hydrocarbon gas processing plant to take up a flow of water from the body of water via the distal end and convey the flow of water to the floating structure through the water intake hose and the proximal end, wherein said water intake hose is mechanically connected to the anchor line at multiple locations along a length of the water intake hose and a length of the anchor line.

[0006] In accordance with a second aspect of the invention, there is provided a method of producing liquefied

natural gas, comprising providing an off-shore hydrocarbon gas processing plant as described above or elsewhere herein, transferring heat from a hydrocarbon gas to a refrigerant stream, taking in a flow of water from the body of water through the water intake hose, and transferring said heat from the refrigerant stream to at least a portion of the flow of water.

[0007] In accordance with a further aspect of the invention, there is provided a method of deploying a floating hydrocarbon gas processing plant arranged on a floating structure, comprising steps of:

- selecting a deployment site off-shore comprising a body of water on a sea bed;
- preparing the deployment site comprising anchoring an anchor line to the sea bed at the deployment site and mechanically connecting a water intake hose to the anchor line at multiple locations along a length of the water intake hose and a length of the anchor line;
- subsequently bringing the floating structure in a position at the deployment site;
- pulling up one end of the anchor line to the floating structure while leaving another end of the anchor line anchored to the sea bed;
- securing the one end of the anchor line to the floating structure;
- securing a proximal end of the water intake hose to the floating structure whereby establishing fluid communication between the water intake hose and the hydrocarbon gas processing plant;

wherein said water intake hose further comprises a distal end projecting away from the floating structure into the body of water to take up a flow of water from the body of water via the distal end and convey the flow of water to the floating structure through the water intake hose and the proximal end.

[0008] The invention will be further illustrated hereinafter by way of example only, and with reference to the nonlimiting drawing in which;

Fig. 1 schematically shows a floating off-shore hydrocarbon processing plant according to an embodiment of the invention;

Fig. 2 schematically shows a cross-sectional view of a first embodiment of a mechanical interconnection between an anchor line and a water intake hose;

Fig. 3 schematically shows a cross-sectional view of a second embodiment of a mechanical interconnection between an anchor line and a water intake hose;

Fig. 4 schematically shows a cross-sectional view of a third embodiment of a mechanical interconnection between an anchor line and a water intake hose;

Fig. 5 schematically illustrates a process flow scheme of a part of a process to produce liquefied natural gas.

[0009] The drawings in these figures are not to scale. For the purpose of this description, a single reference number will be assigned to a line as well as a stream carried in that line. Same reference numbers refer to similar components. The person skilled in the art will readily understand that, while the invention is illustrated making reference to one or more a specific combinations of features and measures, many of those features and measures are functionally independent from other features and measures such that they can be equally or similarly applied independently in other embodiments or combinations.

[0010] In the presently proposed configuration a water intake hose is mechanically connected to an anchor line at multiple locations along a length of the water intake hose and a length of the anchor line.

[0011] This has several benefits. First, as the water intake hose is connected to the anchor line at multiple locations, the anchor line can accommodate tensional forces so that the water intake hose can be made of less strong material than a riser that has to carry its own weight in full, such as is the case with the risers referred to in US Pat. 7,318,387. Further, as the water intake hose is supported by the anchor line, the mechanical connector between the water intake hose and the floating structure can be simpler and/or less robust compared with a water riser that is fully suspended by itself. Thus, a relatively complicated riser hanger as described in US Pat. 7,318,387 may not be necessary.

[0012] In addition, deployment of the floating structure with the hydrocarbon gas processing plant in the off-shore deployment site can be faster, as the water intake hose can be pre-installed on the anchor line and thus deployed at the same time as mooring the floating structure to the anchor line.

[0013] More of the benefits will become clear herein below, as the figures are discussed in more details.

[0014] Figure 1 schematically shows a floating off-shore hydrocarbon gas processing plant 10 arranged on a floating structure 20. The hydrocarbon gas processing plant may comprise a plurality of modules 10a, 10b, 10c, etc., each arranged to carry out different processing steps or functions. The floating structure 20 floats on the surface 120 of a body of water 100 above a sea bed 110. The floating structure 20 is anchored to the sea bed 110 via an anchor line 30. The anchor line 30 is attached to an anchor point 130 on the sea bed 110 and to the floating structure 20 at an engagement point 25.

[0015] Typically, the anchor line 30 descends into the body of water 100 under a distinctly non-zero angle from the vertical direction. Generally the anchor line 30 has at least a suspended part 32 that stretches in the body of water 100 above the sea bed 110 between the sea bed 110 and the floating structure 20. The suspended part 32 may generally be of a free catenary or of a semi-taut configuration.

[0016] In the situation as drawn in Figure 1, the anchor line 30 is so long compared to the depth D of the body

of water that the anchor line 30 comprises a resting part 31 that stretches between the suspended part 32 and the anchor point 130, and lies on the sea bed 110. In that situation, the suspended part 32 stretches between the resting part 31 and the floating structure 20. The suspended part 32 hangs off of the floating structure 20 in the body of water 100 above the sea bed 110.

[0017] A water intake hose 40 is provided, comprising a distal end 41 projecting away from the floating structure 20 into the body of water 100, and a proximal end 42 that is connected to the hydrocarbon gas processing plant 10 to take in a flow of water from the body of water 100 via the distal end 41 and to convey the flow of water to the floating structure 20 through the water intake hose 40 and the proximal end 42. The water intake hose 40 is mechanically connected to the anchor line 30 at multiple locations 50 along a length of the water intake hose 40 and a length of the anchor line 30. In a typical example, the water intake hose 40 may extend along the anchor line 30 over at least 25% of the total length (from the floating structure 20 anchor point 130 of the anchor line 30 to which the water intake hose 40 is mechanically connected).

[0018] Preferably, the floating structure is anchored to the sea bed 110 via a plurality of anchor lines spreading out in a plurality of directions from the floating structure 20. As an example a second anchor line 230 is depicted in Figure 1. At least two of the plurality of anchor lines 30 (230) are each provided with at least one water intake hose 40 (240). Preferably, at most a single water intake hose is mechanically connected to any one anchor line at said multiple locations. An advantage of arranging at least one water intake hose 40 (240) on a plurality of anchor lines spreading out in a plurality of directions is that the probability of all water intake hoses becoming blocked by a large object at the inlets in the distal ends at the same time is very small. Herewith flow of water to the floating structure is assured at all times.

[0019] Preferably, the floating structure 20 comprises a turret 22 and a barge 24. The barge 24 is rotatably connected to the turret 22, whereby the barge 24 can rotate relative to the turret 22 around a vertical axis A, centred in the turret 22. All of the plurality of anchor lines 30 (230) may be connected to the turret 22, each in an engagement point 25 (225).

[0020] The anchor line 30, or each of the anchor lines in the plurality of anchor lines, may be formed of or comprise at least one selected from the group consisting of a cable, a chain, a wire rope, a polyester line, or combinations thereof. The anchor line may be formed of or comprise any suitable material, including preferably steel. The anchor line 30 is preferably a flexible anchor line.

[0021] The water intake hose is suitably formed out of a rubber or a composite material. The composite material may be based on rubber: a preferred example is a rubber reinforced with steel bars. For example, flexible bonded hoses and/or dedicated water intake hoses for FLNG and

FPSO cooling applications, which are suitable for the present water intake hose application, can be obtained from Trelleborg Oil & Marine Corp. Hypochlorite injection lines may be built into the water intake hose.

[0022] The amount of built-in reinforcement into the water intake hose 40 may be less than necessary in self-supported water intake riser configurations, as in accordance with the present invention the water intake hose is mechanically supported by the anchor line 30. This way the anchor line 30 to which the water intake hose 40 is mechanically connected can accommodate (most of) the tensile forces that would otherwise act directly on the water intake hose 40.

[0023] The water intake hose 40, during operation whereby supporting a flow of water from the body of water 100 to the floating structure 20, suitably has an effective density of between 0.8 and 1.3. Herewith the water intake hose 40 is nearly buoyant or just buoyant, such that the gravitational force (or the Archimedes resulting force) that is to be carried by the anchor line 30 is relatively small. Effective density means the density of the hose material (averaged over a representative stretch), divided by the water density of the water in the body of water 100 below the floating structure 20, at a depth half way between the bottom 26 of the floating structure 20 and the sea bed 110. For the purpose of determining depths relative to the bottom 26 of the floating structure 20 in the context of the present description, the bottom 26 of the floating structure 20 is understood to equate to the engagement point 25.

[0024] Preferably, the water intake hose 40, during operation, has an effective density of between 1.0 and 1.3. In this case the water intake hose 40 is neutral or nearly buoyant, such that the resultant additional gravitational force exerted by the water intake riser 40 on the anchor line 30 with which it is mechanically interconnected pulls in downward direction which is preferred from a viewpoint of the anchoring function of the anchor line 30.

[0025] Assuming the water intake hose 40 possesses an essentially circular bore, the inner diameter is preferably selected within a range of from about 25 to 90 cm (10 to 36 inch), preferably in a range of from about 50 to 75 cm (20 to 30 inch). In one example, wherein the flow of water is employed to provide cooling to an natural gas liquefaction process wherein heat removed is removed from natural gas by heat exchange which heat is ultimately discharged using the flow of water supplied in the plurality of water intake hoses, it has been calculated that 16 water intake hoses having an inner diameter of 62 cm or 73 cm could be used (depending on the maximum design flow velocity) to take in a sufficient flow of water or 24 water intake hoses having an inner diameter of 51 cm or 60 cm (assuming the same maximum design flow rates). However, different numbers of water intake hoses and different diameters may be employed depending on the specific circumstances and requirements imposed by the hydrocarbon gas processing plant and other circumstances and design premises.

[0026] In the proposed configuration, the water intake hose 40 can serve to take in water from the body of water 100 from a water intake depth of more than 300 m, preferably deeper than 5 hm, from the surface 120 of the body of water 100. As the anchor line 30 will often be under a non-vertical angle, the actual length of the water intake hose 40 generally needs to be longer than the water intake depth. The water intake hose 40 may extend along the anchor line over at least 60% of the length of the suspended part 32 of the anchor line 30 to which the water intake hose 40 is mechanically connected. This way, water can be taken in from the body of water 100 at a depth of about half way between the bottom 26 of the floating structure 20 and the sea bed 110, or deeper. Preferably the distal end 41 of the water intake hose 40 may be within 2 hm (hectometre) from the sea bed 110.

[0027] However, to avoid taking in solids and other materials from the sea bed, it is recommended to maintain the distal end 41 of the water intake hose 40 at least 0.35 hm above the sea bed (i.e. not closer than about 0.35 hm or 35 m to the sea bed) during normal operations such that in extreme environmental conditions the inlet will not come too close to the sea bed. It is further recommended to limit the length along which the water intake hose 40 extends along the anchor line 30 to within 90% of the length of the suspended part 32 of the anchor line 30 to which the water intake hose 40 is mechanically connected. This allows for some dynamic exchange of the anchor line 30 between resting on the sea bed 110 and being in suspension, whereby the amount of the anchor line 30 in the resting part 31 versus the suspended part 32 may change as a result of lateral movement of the floating structure 20 relative to the anchor point 130 of the anchor line 30.

[0028] The water intake hose 40 may be connected to the anchor line 30 in a variety of ways. One way is to establish a continuous mechanical connection between the two by arranging both the water intake hose 40 and the anchor line 30 in a long sleeve for instance in the form of a long net or one or more strings or lines helically and/or counter helically would over a water intake hose 40 and anchor line 30 couple. Preferably, the water intake hose 40 is slidably connected to the anchor line 30 in the longitudinal direction of the anchor line 30 to avoid loading of mechanical strain from the anchor line 30 on to the water intake hose 40.

[0029] Alternatively, as shown for instance in Figure 1, the mechanical connection between the water intake hose 40 and the anchor line 30 comprises a plurality of mechanical interconnections in discrete contact points at multiple locations along the length of the anchor line 30. The water intake hose 40 may be rigidly interconnected with the anchor line 30 at each of the contact points or have one or more degrees of freedom relative to the anchor line 30.

[0030] An example of a rigid interconnection is illustrated in Figure 2, which shows a cross section of a water intake hose 40 mechanically connected to an anchor line

30. This rigid interconnection comprises an anchor line clamp 61 rigidly clamped around the anchor line 30, a hose clamp 62 clamped rigidly around the water intake hose 40, and a web 63 interconnecting the anchor line clamp 61 with the hose clamp 62. Alternatively, the web 63 may be adhered to or formed as an integral part to the water intake hose 40, thereby omitting the need for the hose clamp 62. Although the elastic strain capacity of the water intake hose may be sufficient to allow a slackless installation, it is recommended with such a rigid interconnection to allow some slack in the water intake hose 40 between successive adjacent contact points to be able to accommodate stretching of the anchor line 30 and/or bending forces from the anchor line 30. In this arrangement, the surface exposed to lateral drag force that can be exerted by the body of water 100 to the anchor line 30 contains the clamps and the web.

[0031] Suitably, the mechanical interconnection between the anchor line 30 and the water intake hose 40 comprises a plurality of discrete guide sleeve distributed along the anchor line 30. Figure 3 shows an example wherein the hose clamp as shown in Figure 2 has been replaced by a hose guide sleeve 64. This allows for a longitudinal movability of the water intake hose 40 relative to the anchor line 30, as a result of which less slack needs to be provided between the connection points 50. The surface exposed to drag is essentially the same as was the case for the rigid interconnection of Figure 2.

[0032] Figure 4 illustrates still another example of a suitable mechanical interconnection, whereby the anchor line clamp 61 of Figure 3 has been replaced by an anchor line guide sleeve 65. The anchor line guide sleeve 65 allows for rotational movability of the hose guide sleeve 64 around the anchor line 30. This allows the water intake hose 40 to weather vane around the anchor line 30 under the influence of a lateral water current, whereby the effective drag surface is reduced to approximately the outer diameter of the larger one of the hose guide sleeve 64 and the outer diameter of the anchor line guide sleeve 65 (the outer diameter of the hose guide sleeve 64 is generally expected to be larger than that of the anchor line guide sleeve 65).

[0033] During operation, the flow of water through the water intake hose 30 may be maintained in any suitable way. Suitably, flow of water through the water intake hose 30 may be maintained by a water pump provided in the floating structure. However, alternatives may be explored, such as employing siphon action as proposed in e.g. US patent 6,832,875.

[0034] If the water intake hose 40 is connected to the turret 22, there are various techniques available to transfer the water from the turret 22 to the barge 24 including for instance swivel technology of which an example is disclosed in US Patent 6,845,727 and an alternative technology of which an example is published in e.g. WO 2004/069643.

[0035] The off-shore hydrocarbon gas processing plant 10 described above may be employed for producing

liquefied natural gas (LNG). The proposed configuration of the water intake hose on the anchor line offers the benefit of being able to take in water from larger depths than is possible with free-hanging risers deployed from the aft of the floating structure. This means that the water can be taken in at a lower temperature, generally resulting in a higher production rate of LNG using the same plant power and equipment.

[0036] As an example, the floating structure 20 may comprise all equipment necessary to produce natural gas from a sub-sea gas well and to subject the produced natural gas to all hydrocarbon processing steps necessary to condition the natural gas for liquefaction and then subsequently to liquefy the conditioned natural gas. Liquefying in the present context comprises transferring heat from a hydrocarbon gas 310, which may be in the form of the pre-conditioned natural gas, to a refrigerant stream 320. These streams are shown in Figure 5, wherein both the hydrocarbon gas 310 and the refrigerant stream 320 pass through an indirect heat exchanger 330 in indirect heat exchanging contact with each other. The refrigerant stream, containing the heat removed from the hydrocarbon gas 310, is withdrawn from the indirect heat exchanger 330 in line 340 and passed to a compressor 350 for recompression. The refrigerant stream as discharged from the compressor 350, in line 360, now contains not only the heat removed from the hydrocarbon gas 310, but also compression heat that has been added during compression of the refrigerant stream from line 340. The heat removed from the hydrocarbon gas 310, together with the compression heat, are then transferred from the refrigerant stream in line 360 to at least a portion in line 370 of the flow of water taken in from the body of water 100 through the water transfer hose 40. To this end, both line 370 and line 360 are brought into indirect heat exchanging contact in a water cooler 380. The refrigerant stream in line 360 is subsequently auto-refrigerated in indirect heat exchanger 330 and passed through an expansion device 390 (for instance, a Joule-Thomson valve) before again being passed through the indirect heat exchanger 330.

[0037] The natural gas (e.g. the hydrocarbon gas 310) may also be cooled against part of the water taken in via the water intake hose 40, prior to being fed to the indirect heat exchanger 330.

[0038] The person skilled in the art will understand that a large variety of suitable processes for producing liquefied natural gas is known and can be used in combination with the present invention. Figure 5 merely serves to illustrate one example of a part of such a processes.

[0039] The off-shore floating hydrocarbon gas processing plant as described above can be deployed by bringing the floating structure with the hydrocarbon gas processing plant in a position at a selected off-shore deployment site, anchoring the floating structure at the deployment site and subsequently deploying the one or more water intake hoses along one or more of the anchor lines. The deployment site may be prepared by at least

anchoring the desired number of anchor lines (30,230) to the sea bed at the deployment site before the floating structure is brought in from a geographically different site such as its construction site or a site of a previous deployment.

[0040] However, the concept of mechanically interconnecting the water intake hose 40 with the anchor line 30 allows for a new approach, wherein during the preparation of the deployment site the desired number of water intake hoses (40,240) is already pre-installed by mechanically connecting to the respective anchor lines (30,230) as described above. After the floating structure 20 is subsequently brought in a position at the deployment site, one end of the anchor line 30 or each of the anchor lines (30,230) may be pulled up to the floating structure 20, while leaving the other end of the anchor line anchored to the sea bed 110 in the anchor point 130. The end(s) of the anchor line(s) (30,230) being pulled up to the floating structure 20 may then be secured to the floating structure 20 at the respective engagement point(s) (25,225). Having completed these steps, the proximal end 42 of the water intake hose 30 is then ready to be fluidly connected to the floating structure 20 without the need to take time to deploy.

[0041] The person skilled in the art will understand that the present invention can be carried out in many various ways without departing from the scope of the appended claims.

Claims

1. A floating off-shore hydrocarbon gas processing plant (10) arranged on a floating structure (20), wherein said floating structure (20) floats on a body of water (100) above a sea bed (110), wherein the floating structure (20) is anchored to the sea bed (110) via an anchor line (30, 230) being attached to an anchor point (130) on the sea bed (110), and wherein a water intake hose (40) is provided comprising a distal end (41) projecting away from the floating structure (20) into the body of water (100) and a proximal end (42) that is connected to the hydrocarbon gas processing plant (10) to take up a flow of water from the body of water (100) via the distal end (41) and convey the flow of water to the floating structure (20) through the water intake hose (40) and the proximal end (42), **characterized in that** said water intake hose (40) is mechanically connected to the anchor line (30, 230) at multiple locations (50) along a length of the water intake hose (40) and a length of the anchor line (30, 230).
2. The floating off-shore hydrocarbon gas processing plant of claim 1, wherein the floating structure (20) is anchored to the sea bed (110) via a plurality of anchor lines (30, 230) spreading out in a plurality of directions from the floating structure (20).
3. The floating off-shore hydrocarbon gas processing plant of claim 1 or 2, wherein the floating structure (20) comprises a turret (22) and a barge (24), wherein the anchor lines (30, 230) are connected to the turret (22) and wherein the barge (24) is rotatably connected to the turret (22) whereby the barge (24) can rotate relative to the turret (22) around a vertical axis (A) 30 centred in the turret (22).
4. The floating off-shore hydrocarbon gas processing plant of claim 2 or 3, wherein at least two of the plurality of anchor lines (30, 230) are each provided with at least one water intake hose, (40) wherein each at least one water intake hose (40) is mechanically connected to exclusively one of the plurality of anchor lines (30, 230) at multiple locations (50) along the water intake hose (40) and said exclusively one of the plurality of anchor lines (30, 230).
5. The floating off-shore hydrocarbon gas processing plant of any one of the preceding claims, wherein the water intake hose (40) extends along the anchor line (30, 230) over at least 25% of the length of the anchor line to which the water intake hose is mechanically connected.
6. The floating off-shore hydrocarbon gas processing plant of any one of the preceding claims, wherein the anchor line (30, 230) comprises a suspended part that stretches in the body of water above the sea bed (110) between the sea bottom and the floating structure (20), wherein the water intake hose (40) extends along the anchor line over at least 60% of the length of the suspended part of the anchor line (30, 230) to which the water intake hose (40) is mechanically connected.
7. The floating off-shore hydrocarbon gas processing plant of claim 6, wherein the water intake hose (40) extends along the anchor line (30, 230) to within 90% of the length of the suspended part of the anchor line to which the water intake hose (40) is mechanically connected.
8. The floating off-shore hydrocarbon processing plant of any one of the preceding claims, wherein the distal end (41) of the water intake hose (40) is at deeper than 3 hm (hectometre) from the surface of the body of water.
9. The floating off-shore hydrocarbon gas processing plant of any one of the preceding claims, wherein the distal end (41) of the water intake hose (40) is 2 hm or less above the sea bed.
10. The floating off-shore hydrocarbon gas processing plant of claim 9, wherein the distal end (41) of the water intake hose (40) is 0.5 hm or more above the

sea bed.

11. The floating off-shore hydrocarbon gas processing plant of any one of the preceding claims, wherein the water intake hose (40) during operation has an effective density of between 0.8 and 1.3.
12. The floating off-shore hydrocarbon gas processing plant of any one of claims 1 to 9, wherein the water intake hose (40) during operation has an effective density of between 1.0 and 1.3.
13. The floating off-shore hydrocarbon gas processing plant of any one of the preceding claims, wherein the water intake hose (40) is formed out of a rubber and/or a composite material.
14. A method of deploying a floating hydrocarbon gas processing plant (10) arranged on a floating structure (20), comprising steps of:

- selecting a deployment site off-shore comprising a body of water (100) on a sea bed (110);
- preparing the deployment site comprising anchoring an anchor line (30, 230) to the sea bed at the deployment site and mechanically connecting a water intake hose (40) to the anchor line (30, 230) at multiple locations (50) along a length of the water intake hose (40) and a length of the anchor line;
- subsequently bringing the floating structure (20) in a position at the deployment site;
- pulling up one end of the anchor line (30, 230) to the floating structure (20) while leaving another end of the anchor line anchored to the sea bed (110);
- securing the one end of the anchor line (30, 230) to the floating structure (20);
- securing a proximal end (42) of the water intake hose to the floating structure (20) whereby establishing fluid communication between the water intake hose (40) and the hydrocarbon gas processing plant;

wherein said water intake hose (40) further comprises a distal end (41) projecting away from the floating structure (20) into the body of water to take up a flow of water from the body of water via the distal end (41) and convey the flow of water to the floating structure (20) through the water intake hose (40) and the proximal end (41).

15. Method of producing liquefied natural gas, comprising providing an off-shore hydrocarbon gas processing plant (10) in accordance with any one of claims 1 to 13, transferring heat from a hydrocarbon gas to a refrigerant stream, taking in a flow of water from the body of water through the water intake hose, and

transferring said heat from the refrigerant stream to at least a portion of the flow of water.

5 Patentansprüche

1. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage (10), die auf einer schwimmenden Struktur (20) angeordnet ist, wobei die schwimmende Struktur (20) auf einem Gewässer (100) über einem Grund (110) schwimmt, wobei die schwimmende Struktur (20) über eine Ankerleine (30, 230), die an einem Ankerpunkt (130) auf dem Grund (110) befestigt ist, an dem Grund (110) verankert ist, und wobei ein Wassereinlassschlauch (40) vorgesehen ist, der ein distales Ende (41), das von der schwimmenden Struktur (20) auswärts in das Gewässer (100) ragt, und ein proximales Ende (42), das mit der Kohlenwasserstoffgasverarbeitungsanlage (10) verbunden ist, umfasst, um einen Wasserstrom von dem Gewässer (100) über das distale Ende (41) aufzunehmen und den Wasserstrom durch den Wassereinlassschlauch (40) zu der schwimmenden Struktur (20) und dem proximalen Ende (42) zu befördern, **dadurch gekennzeichnet, dass** der Wassereinlassschlauch (40) mit der Ankerleine (30, 230) an mehreren Orten (50) entlang einer Länge des Wassereinlassschlauchs (40) und einer Länge der Ankerleine (30, 230) mechanisch verbunden ist.
2. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach Anspruch 1, wobei die schwimmende Struktur (20) auf dem Grund (110) über mehrere Ankerleinen (30, 230), die sich in mehrere Richtungen von der schwimmenden Struktur (20) ausbreiten, verankert ist.
3. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach Anspruch 1 oder 2, wobei die schwimmende Struktur (20) eine Luke (22) und einen Kahn (24) umfasst, wobei die Ankerleinen (30, 230) mit der Luke (22) verbunden sind und wobei der Kahn (24) mit der Luke (22) drehbar verbunden ist, wobei sich der Kahn (24) in Bezug auf die Luke (22) um eine vertikale Achse (A), die auf die Luke (22) zentriert ist, drehen kann.
4. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach Anspruch 2 oder 3, wobei mindestens zwei der mehreren Ankerleinen (30, 230) jeweils mit einem Wassereinlassschlauch (40) ausgestattet sind, wobei jeder des mindestens einen Wassereinlassschlauchs (40) mit ausschließlich einer der mehreren Ankerleinen (30, 230) an mehreren Orten (50)

entlang des Wassereinlassschlauchs (40) und der ausschließlich einen der mehreren Ankerleinen (30, 230) mechanisch verbunden ist.

5. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach einem der vorangehenden Ansprüche, wobei sich der Wassereinlassschlauch (40) über mindestens 25 % der Länge der Ankerleine entlang der Ankerleine (30, 230) erstreckt, mit der der Wassereinlassschlauch mechanisch verbunden ist. 5
6. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach einem der vorhergehenden Ansprüche, wobei die Ankerleine (30, 230) einen hängenden Teil umfasst, der sich in dem Gewässer über dem Grund (110) zwischen dem Meeresboden und der schwimmenden Struktur (20) erstreckt, wobei sich der Wassereinlassschlauch (40) über mindestens 60 % der Länge des hängenden Teils der Ankerleine (30, 230) entlang der Ankerleine (30, 230) erstreckt, mit der der Wassereinlassschlauch (40) mechanisch verbunden ist. 10 20
7. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach Anspruch 6, wobei sich der Wassereinlassschlauch (40) innerhalb von 90 % der Länge des hängenden Teils der Ankerleine entlang der Ankerleine (30, 230) erstreckt, mit der der Wassereinlassschlauch (40) mechanisch verbunden ist. 25 30
8. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach einem der vorhergehenden Ansprüche, wobei sich das distale Ende (41) des Wassereinlassschlauchs (40) tiefer als 3 hm (Hektometer) von der Oberfläche des Gewässers befindet. 35
9. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach einem der vorhergehenden Ansprüche, wobei sich das distale Ende (41) des Wassereinlassschlauchs (40) 2 hm oder weniger über dem Grund befindet. 40
10. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach Anspruch 9, wobei sich das distale Ende (41) des Wassereinlassschlauchs (40) 0,5 hm oder mehr über dem Grund befindet. 45
11. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach einem der vorhergehenden Ansprüche, wobei der Wassereinlassschlauch (40) während des Betriebs eine effektive Dichte in einem Bereich von 0,8 bis 1,3 besitzt. 50
12. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach einem der Ansprüche 1 bis 9, wobei der Wassereinlassschlauch (40) während

des Betriebs eine effektive Dichte in einem Bereich von 1,0 bis 1,3 besitzt.

13. Schwimmende Offshore-Kohlenwasserstoffgasverarbeitungsanlage nach einem der vorhergehenden Ansprüche, wobei der Wassereinlassschlauch (40) aus einem Gummi und/oder einem Verbundmaterial gebildet ist. 5

14. Verfahren zum Einsetzen einer schwimmenden Kohlenwasserstoffgasverarbeitungsanlage (10), die auf einer schwimmenden Struktur (20) angeordnet ist, das die folgenden Schritte umfasst: 10

- Auswählen eines Einsatzorts vor der Küste, der ein Gewässer (100) auf einem Grund (110) umfasst, 15
- Vorbereiten des Einsatzorts, das umfasst, eine Ankerleine (30, 230) an dem Grund an dem Einsatzort zu verankern und einen Wassereinlassschlauch (40) mit der Ankerleine (30, 230) an mehreren Orten (50) entlang einer Länge des Wassereinlassschlauchs (40) und einer Länge der Ankerleine mechanisch zu verbinden; 20
- anschließend Bringen der schwimmenden Struktur (20) in eine Position an dem Einsatzort;
- Einziehen eines Endes der Ankerleine (30, 230) zu der schwimmenden Struktur (20), während ein anderes Ende der Ankerleine auf dem Grund (110) verankert gelassen wird;
- Befestigen des einen Endes der Ankerleine (30, 230) an der schwimmenden Struktur (20);
- Befestigen eines proximalen Endes (42) des Wassereinlassschlauchs an der schwimmenden Struktur (20), wodurch eine Fluidkommunikation zwischen dem Wassereinlassschlauch (40) und der Kohlenwasserstoffgasverarbeitungsanlage eingerichtet wird; 25

wobei der Wassereinlassschlauch (40) ferner ein distales Ende (41), das von der schwimmenden Struktur (20) auswärts in das Gewässer ragt, umfasst, um einen Wasserstrom von dem Gewässer über das distale Ende (41) aufzunehmen und den Wasserstrom durch den Wassereinlassschlauch (40) und das proximale Ende (41) zu der schwimmenden Struktur (20) zu befördern. 30

15. Verfahren des Herstellens eines verflüssigten Erdgases, das umfasst, eine Offshore-Wasserkohlenstoffgasverarbeitungsanlage (10) nach einem der Ansprüche 1 bis 13 bereitzustellen, die Wärme von einem Wasserkohlenstoffgas an einen Kühlmittelstrom zu übertragen, einen Wasserstrom von dem Gewässer durch den Wassereinlassschlauch aufzunehmen und die Wärme von dem Kühlmittelstrom an mindestens einen Teil des Wasserstroms zu übertragen. 35 40 45 50 55

Revendications

1. Usine flottante (10) de traitement de gaz d'hydrocarbures en mer disposée sur une structure flottante (20), ladite structure flottante (20) flottant sur une étendue d'eau (100) au-dessus d'un fond marin (110), la structure flottante (20) étant ancrée au fond marin (110) via une ligne (30, 230) d'ancrage qui est fixée à un point (130) d'ancrage sur le fond marin (110), et un tuyau souple (40) de prise d'eau étant mis en place, comportant une extrémité distale (41) dépassant à l'écart de la structure flottante (20) jusque dans l'étendue d'eau (100) et une extrémité proximale (42) qui est reliée à l'usine (10) de traitement de gaz d'hydrocarbures pour prélever un écoulement d'eau à partir de l'étendue d'eau (100) via l'extrémité distale (41) et acheminer l'écoulement d'eau jusqu'à la structure flottante (20) à travers le tuyau souple (40) de prise d'eau et l'extrémité proximale (42), **caractérisé en ce que** ledit tuyau souple (40) de prise d'eau est relié mécaniquement à la ligne (30, 230) d'ancrage à des emplacements multiples (50) sur une longueur du tuyau souple (40) de prise d'eau et une longueur de la ligne (30, 230) d'ancrage.
2. Usine flottante de traitement de gaz d'hydrocarbures en mer selon la revendication 1, la structure flottante (20) étant ancrée au fond marin (110) via une pluralité de lignes (30, 230) d'ancrage s'écartant dans une pluralité de directions à partir de la structure flottante (20).
3. Usine flottante de traitement de gaz d'hydrocarbures en mer selon la revendication 1 ou 2, la structure flottante (20) comportant une tourelle (22) et une barge (24), les lignes (30, 230) d'ancrage étant reliées à la tourelle (22) et la barge (24) étant liée de façon pivotante à la tourelle (22), de sorte que la barge (24) peut tourner par rapport à la tourelle (22) autour d'un axe vertical (A) centré dans la tourelle (22).
4. Usine flottante de traitement de gaz d'hydrocarbures en mer selon la revendication 2 ou 3, au moins deux lignes de la pluralité de lignes (30, 230) d'ancrage étant chacune munie d'au moins un tuyau souple (40) de prise d'eau, ledit ou chacun desdits tuyaux souples (40) de prise d'eau étant relié mécaniquement exclusivement à une ligne de la pluralité de lignes (30, 230) d'ancrage à des emplacements multiples (50) le long du tuyau souple (40) de prise d'eau et de ladite ligne exclusivement unique de la pluralité de lignes (30, 230) d'ancrage.
5. Usine flottante de traitement de gaz d'hydrocarbures en mer selon l'une quelconque des revendications précédentes, le tuyau souple (40) de prise d'eau s'étendant le long de la ligne (30, 230) d'ancrage sur au moins 25% de la longueur de la ligne d'ancrage à laquelle est relié mécaniquement le tuyau souple de prise d'eau.
6. Usine flottante de traitement de gaz d'hydrocarbures en mer selon l'une quelconque des revendications précédentes, la ligne (30, 230) d'ancrage comportant une partie suspendue qui s'étire dans l'étendue d'eau au-dessus du fond marin (10) entre le fond de la mer et la structure flottante (20), le tuyau souple (40) de prise d'eau s'étendant le long de la ligne d'ancrage sur au moins 60% de la longueur de la partie suspendue de la ligne (30, 230) d'ancrage à laquelle est relié mécaniquement le tuyau souple (40) de prise d'eau.
7. Usine flottante de traitement de gaz d'hydrocarbures en mer selon la revendication 6, le tuyau souple (40) de prise d'eau s'étendant le long de la ligne (30, 230) d'ancrage à concurrence de 90% de la longueur de la partie suspendue de la ligne d'ancrage à laquelle est relié mécaniquement le tuyau souple (40) de prise d'eau.
8. Usine flottante de traitement d'hydrocarbures en mer selon l'une quelconque des revendications précédentes, l'extrémité distale (41) du tuyau souple (40) de prise d'eau se trouvant à plus de 3 hm (hectomètres) de profondeur par rapport à la surface de l'étendue d'eau.
9. Usine flottante de traitement de gaz d'hydrocarbures en mer selon l'une quelconque des revendications précédentes, l'extrémité distale (41) du tuyau souple (40) de prise d'eau se trouvant à au plus 2 hm au-dessus du fond marin.
10. Usine flottante de traitement de gaz d'hydrocarbures en mer selon la revendication 9, l'extrémité distale (41) du tuyau souple (40) de prise d'eau se trouvant à au moins 0,5 hm au-dessus du fond marin.
11. Usine flottante de traitement de gaz d'hydrocarbures en mer selon l'une quelconque des revendications précédentes, le tuyau souple (40) de prise d'eau présentant, en cours d'exploitation, une densité effective comprise entre 0,8 et 1,3.
12. Usine flottante de traitement de gaz d'hydrocarbures en mer selon l'une quelconque des revendications 1 à 9, le tuyau souple (40) de prise d'eau présentant, en cours d'exploitation, une densité effective comprise entre 1,0 et 1,3.
13. Usine flottante de traitement de gaz d'hydrocarbures en mer selon l'une quelconque des revendications précédentes, le tuyau souple (40) de prise d'eau étant formé à partir d'un caoutchouc et/ou d'un matériau composite.

14. Procédé de déploiement d'une usine flottante (10) de traitement de gaz d'hydrocarbures disposée sur une structure flottante (20), comportant les étapes consistant à :

- sélectionner un site de déploiement en mer comportant une étendue d'eau (100) sur un fond marin (110) ;
- préparer le site de déploiement, ce qui comporte les étapes consistant à ancrer une ligne (30, 230) d'ancrage au fond marin sur le site de déploiement et à relier mécaniquement un tuyau souple (40) de prise d'eau à la ligne (30, 230) d'ancrage à des emplacements multiples (50) sur une longueur du tuyau souple (40) de prise d'eau et une longueur de la ligne d'ancrage ;
- amener ensuite la structure flottante (20) dans une position sur le site de déploiement ;
- hisser une extrémité de la ligne (30, 230) d'ancrage jusqu'à la structure flottante (20) tout en laissant une autre extrémité de la ligne d'ancrage ancrée au fond marin (110) ;
- arrimer l'extrémité en question de la ligne (30, 230) d'ancrage à la structure flottante (20) ;
- arrimer une extrémité proximale (42) du tuyau souple de prise d'eau à la structure flottante (20), établissant ainsi une communication fluïdique entre le tuyau souple (40) de prise d'eau et l'usine de traitement de gaz d'hydrocarbures ;

ledit tuyau souple (40) de prise d'eau comportant en outre une extrémité distale (41) dépassant à l'écart de la structure flottante (20) jusque dans l'étendue d'eau pour prélever un écoulement d'eau à partir de l'étendue d'eau via l'extrémité distale (41) et acheminer l'écoulement d'eau jusqu'à la structure flottante (20) à travers le tuyau souple (40) de prise d'eau et l'extrémité proximale (41).

15. Procédé de production de gaz naturel liquéfié, comportant les étapes consistant à mettre en place une usine (10) de traitement de gaz d'hydrocarbures en mer selon l'une quelconque des revendications 1 à 13, à transférer de la chaleur d'un gaz d'hydrocarbures à un flux d'agent frigorigène, à admettre un écoulement d'eau à partir de l'étendue d'eau à travers le tuyau souple de prise d'eau, et à transférer ladite chaleur du flux d'agent frigorigène à au moins une partie de l'écoulement d'eau.

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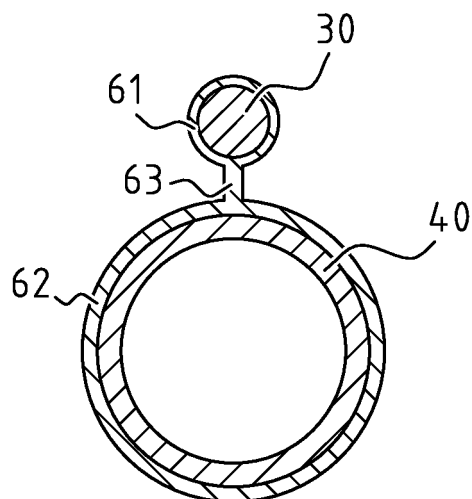
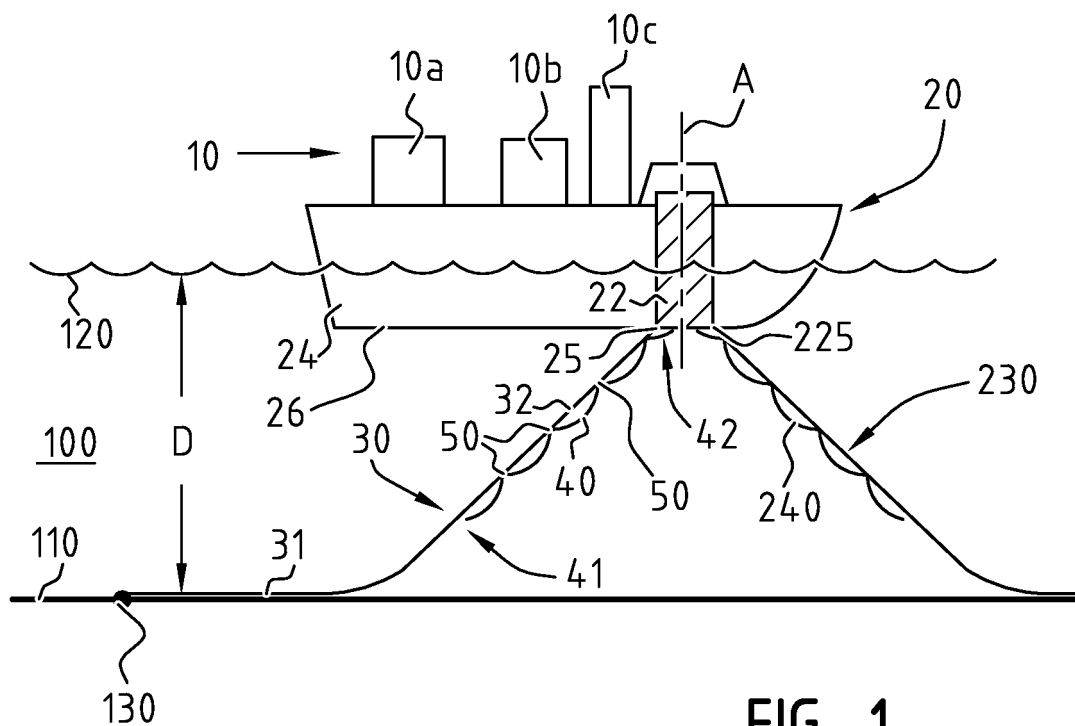
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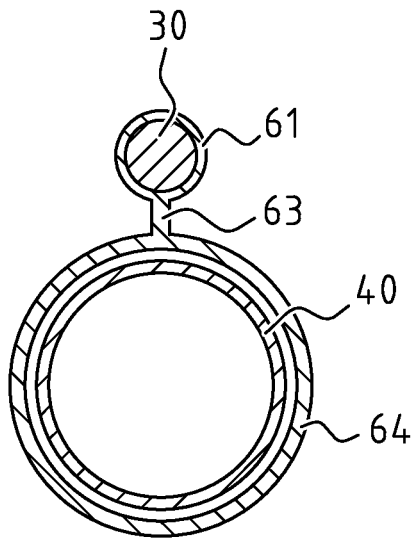


FIG. 3

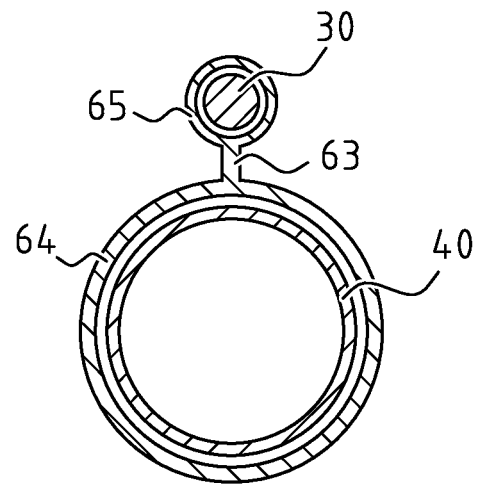


FIG. 4

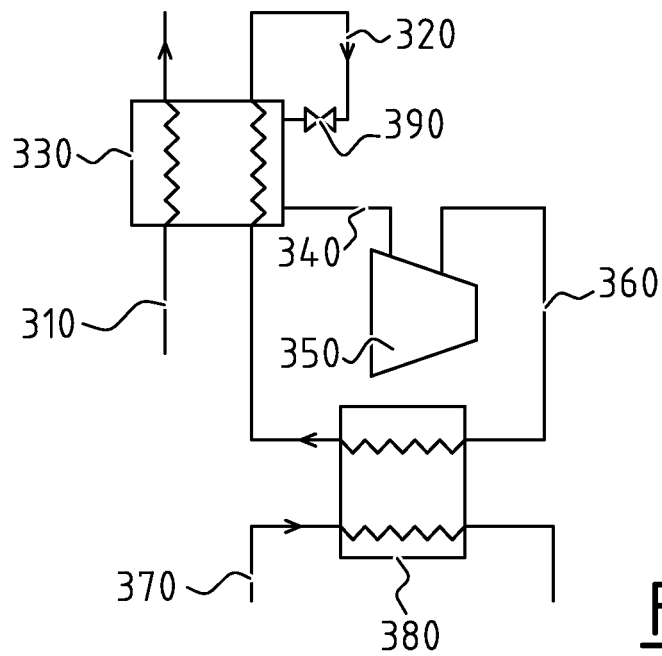


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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