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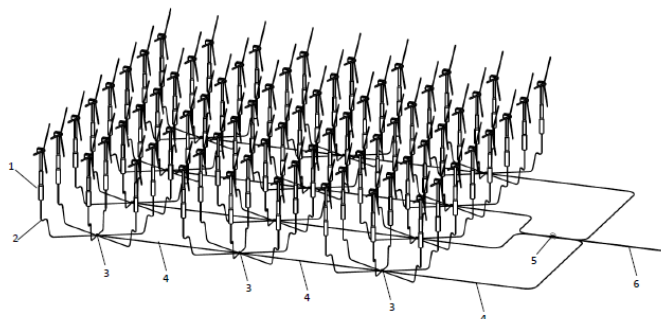
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| (54) | Title | Subsea hydrogen distribution from decentralized producers | | |
| (56) | References Cited: | WO 2020/095012 A1, GB 2299108 A, WO 2018/045357 A1, WO 2020/157509 A1, WO 2016/044910 A1, US 2018/0371877 A1 | | |
| (57) | Abstract | | | |

The present invention relates to a hydrogen production field layout comprising a decentralized hydrogen producer 1 at surface or at the seabed, a Jumper/riser 2 to a subsea inline manifold 3 with two or more inlets that is connected to an infield flowline 4. One or more inline manifolds 3 to be connected to the infield flowline 4. The infield flowline 4 can either be an export line directly to end station or be routed to a pipeline end manifold 5 to collect several infield flowlines 4 to an export pipeline 6. The export pipeline 6 can either be merged into an existing export line or be routed directly to a storage unit or consumer onshore or offshore. A boosting unit 25 can be included at the pipeline end manifold 5 or connected to the export pipeline 6 if required.



Subsea hydrogen distribution from decentralized producers

The present invention relates to a field configuration or layout of a pipeline system consisting of infield flowline and export pipeline in connection with a subsea inline manifold utilized in connection with a decentralized hydrogen producer at surface or at seabed, in particular for producing hydrogen or a mixture with hydrogen. The present invention is intended utilized for distribution of hydrogen from a number of decentralized hydrogen producers, typically in the context of a wind power farm, solar power, or wave/tidewater power farms.

In this context, related prior art can be found in, e.g., WO2020/095012 A1 disclosing an offshore wind turbine system for the large-scale production of hydrogen. The system includes a floating tower structure, a wind turbine generator, a lift pump, a desalination unit, an electrolysis unit, and an export riser. The hydrogen generated by the electrolysis unit is provided to the export riser for delivery to a manifold or pipeline that may be deployed upon the sea floor.

GB2299108 A and WO2018/045357 A1 disclose examples of subsea distribution networks in connection with hydrocarbon production.

WO2020/157509 A1, WO2016/044910 A1 and US2018/0371877 A1 disclose examples of subsea manifolds for oil and gas operations.

The present invention provides a subsea hydrogen distribution system for transport of hydrogen comprising:

- a number of hydrogen producers arranged at surface or at seabed in decentralized positions relative to a subsea inline manifold;
- a jumper/riser connecting each hydrogen producer with the subsea inline manifold;
- the subsea inline manifold comprising a manifold module and an inline Tee, the manifold module having a branch connection for each jumper/riser, the branch connections in flow connection with an infield flowline via a vertical up-facing hub integrated in the inline Tee; and
- the infield flowline connecting the subsea inline manifold to a pipeline end manifold or an export pipeline.

The manifold module comprises a compiler fitting formed with a vertical bore leading from an integrated or assembled down-facing connection to each branch connection, a manifold branch valve integrated with each branch connection. The down-facing connection is arranged for connection to the up-facing hub of the inline Tee. The inline Tee has an isolation valve integrated in the vertical up-facing hub in order to avoid flooding of the infield flowline while connecting or disconnecting the manifold module.

The present invention further comprises the following embodiments according to the appended subordinated patent claims:

- the manifold module comprises a lifting interface to allow a manifold lifting tool to be fixed to the manifold module for guiding, installation and retrieval;
- the inline Tee is designed with a rigid inline Tee header prepared with a flowline interface, such as a flange or other type of connection, at one or at each end, allowing a flexible infield flowline or export pipeline to be connected;
- the inline Tee is equipped with retractable guideposts to guide the manifold module during landing and retrieval;
- the inline Tee can be installed with or without the manifold module when laying out the infield flowline;
- a subsea boosting unit is connected to the export pipeline via inline Tees and upstream and downstream of an x-over valve allowing hydrogen flow to be routed via the boosting unit;
- the subsea boosting unit is arranged onto a fixed or floating unit at surface, and wherein a connection system allows flow to be routed to surface via risers.

The invention is driven to achieve a flexible and independent system, allowing the hydrogen production and distribution to start up at any stage in the field development unlike a daisy chain type solution where the producers must be installed in a fixed sequence or fully completed before the production can start. The only installation needed before start of hydrogen export is minimum one hydrogen producer 1, the infield flowline 4 with the inline-Tee's, 9, and the manifold module 8 connected for the relevant producer.

The infield flowline 4, typical 8" to 16" to be connected to inline Tee's 9 that are configured with a vertical inlet 17 of typical 5" to 7" bore with a manual isolation valve 15 with an integrated up-facing hub 16. The inline Tee 9 header 36 can either be welded or flanged to the infield flowline 4 via the flowline interface 35. A

manifold module 8 with a compiler fitting 13 with two or more branch connections 12 to be landed vertically on the inline Tee 9 up-facing hub 16 and secured by a clamp, collet, or similar type of down-facing connection 14. Each branch on the manifold module 8 is equipped with a manifold branch valve 11 typically 2" to 4" bore. The compiler fitting 13 will be drilled with a vertical bore from the down-facing connection 14 and out to each of the branch connections 12 through the manifold branch valve 11. The manifold 8 can be installed together with the inline Tee 9 or separately. If the manifold module 8 is not installed a subsea cap can be installed on the Inline Tee 9 up-facing hub 16. The inline Tee 9 isolation valve 15 to be manually operated, the isolation valve 15 to be opened after the manifold module 8 is installed and secured in order to avoid the infield flowline 4 to be flooded with seawater, or hydrogen to leak out in case production is ongoing at other locations in the field. A lifting tool 41 is used to retrieve and install the manifold module 8. Guide sleeves 39 on the lifting tool 41 ensuring guiding towards the inline Tee 9. The Inline Tee 9 has two of retractable guideposts 43 for guiding of the manifold module. The retractable guideposts 43 are extended by tension from guide wires 37 anchored to the guidewire anchor receptacle 34 on the top of the retractable guideposts 43. Guide wire 37 can be used to guide the manifold module 8 or be removed after extending the retractable guideposts 43 if guide wires are not required.

A typical 2" to 4" jumper/riser 2 to be connected between the hydrogen producer 1 and the inline manifold 3, these connections can typical be a subsea remotely operated vehicle operated stab connection 33. The jumper/riser 2 to be a riser type if hydrogen producer sits on a floating unit or pulled through a J-tube in case the installation sits on a jack-up type foundation. A dry mate manual type connection can be used at the hydrogen producer end of the jumper/riser in a surface configuration.

The invention allows for a more optimized and standardized pipe sizing than a daisy chain solution as the jumper/riser 2 from each producer. Any start-up, maintenance, shutdown or removal of a hydrogen producer 1 will not affect the remaining production from other hydrogen producers 1 in the field as it can be isolated at the manifold module 8. Connecting the infield flowlines 4 into an export pipeline end

manifold 5 also allows flexibility to start up production when installing only one infield flowline 4 and later implement additional.

The system is optimized to reduce the need for large flowline connections. The only flowline connections are between the infield flowline 4 and pipeline end manifold 5. The large export pipeline 6, typical 28" to 42" out from the pipeline end manifold 5 can be welded/connected at surface and installed as one unit and will also avoid any additional pipeline end termination and spool. The pipeline end manifold 5 can be designed as a sledge to take any possible temperature and/or pressure expansions.

The export pipeline 6 can be installed dry as there are valves 22 on each of the pipeline end manifold 5 branches. If required, a de-watering pig can be pre-installed inside the pipeline end manifold 5, pushing water back to shore or another subsea application if the export pipeline 6 requires to be flooded during installation. A retrievable pig launcher can also be installed for de-watering, but this will require an end connection and a valve on the export pipeline 6 end matching the export pipeline 6 size. De-watering of the infield flowlines 4 can be done by pre-installing a de-watering pig at the back end of the outermost inline manifold 3 and then run the pig towards the pipeline end manifold 5. An integrated pig stop can be installed at the pipeline end manifold 5 branch, preventing the pig from entering into the pipeline end manifold 5 inboard pipe. The pig can then be returned back to starting point and be secured by a manual operated pig stopper. An alternative can be to use a retrievable pig launcher at outermost inline manifold 3 with the impact of adding a connection system and an isolation valve matching the infield flowline 4 size.

All lines in the system e.g. jumper/riser 2, infield flowlines 4, and export pipeline 6 can be either flexible or rigid. Layout presented indicates flexible riser 2 and infield flowline 4, export pipeline 6 is shown as rigid.

A boosting station can be added in case of long-distance export line or if higher pressure is required for other reasons. The boosting station can either be added to the pipeline end manifold 5 or be included as a surface or subsea standalone boosting unit 25 in fluid connection with the export pipeline 6 downstream the pipeline end manifold 5. An inline Tee 27 upstream export line x-over valve 26 and an inline Tee 30 downstream the export line x-over valve 26 allow the flow to be routed via the boosting unit 25 when closing the x-over valve 26. The Isolation valves 29 to be closed when removing the boosting unit 25 or when not in service. Connection system 28 allow boosting station to be connected or disconnected. The

connection 28 can be connected to a riser if the boosting station is located on a jack-up, floating unit or similar. This solution also allows the boosting station to be included at any time without disturbing the hydrogen production.

5 Short description of the drawings

Fig. 1 is an isometric view of a Typical none scaled subsea hydrogen distribution field layout;

10 Fig. 2 is a partial top view of a Typical none scaled subsea hydrogen distribution field layout;

Fig. 3 is a partial isometric view of a none scaled decentralized hydrogen production with an inline manifold 3 collecting hydrogen into an infield flowline 4;

Fig. 4 is an isometric view of jumpers/risers 2 and an inline manifold 3, connected to infield flowline 4;

15 Fig. 5 is an exploded view of an inline manifold 3 showing an inline Tee 9 with manifold module 8 and inline manifold protection cover 7;

Fig. 6 is an isometric view showing manifold module 8 being installed/retrieved onto/from the inline Tee 9, lifted by a lifting tool 41 and guided by guide wires 37;

20 Fig. 7 is an isometric view showing manifold module 8 landed onto the inline Tee 9, lifted by a lifting tool 41;

Fig. 8 is an isometric view showing manifold module 8 landed out onto the inline Tee 9, lifting tool 41 removed and guideposts 43 retracted;

Fig. 9 is an isometric view of a hydrogen export pipeline end manifold 5 in service;

25 Fig. 10 is an isometric view of a hydrogen export pipeline end manifold module 5; and

Fig. 11 is a schematic view of a Tee'ed off subsea or surface boosting station 25 connected to the hydrogen export pipeline 6.

30 Detailed description of an embodiment of the invention with reference to the drawings

Fig. 1 is an isometric representation of a field configuration of the present invention. A decentralized hydrogen producer 1 shown as part of a windmill. A jumper/riser 2 from the hydrogen producer 1 and down to an inline manifold 3. Infield flowlines 4
35 connecting the inline manifolds 3 to an export pipeline end manifold 5. An export pipeline 6 connected to the pipeline end manifold 5.

Fig. 2 is a top view representing parts of the present invention as described in figure 1. Decentralized hydrogen producer 1 shown as a dot at the end of the Jumper/riser 2.

Fig. 3 is an isometric representation, representing one hydrogen production center of the present invention. The figure shows six of decentralized hydrogen producers 1 integrated into windmill, with a Jumper/riser 2 between the producer 1 and the inline manifold 3 at the seabed floor. Infield flowlines 4 connected to the inline manifold 3.

Fig. 4 is an isometric view of the inline manifold 3, shown with the Jumper/riser 2 from the producers and infield flowline 4 connected with a stab connection 33. This version shows the infield flowline 4 connected to the inline Tee header 36 via the flowline interface 35, in this case a flange type connection.

Fig. 5 is an exploded view of the inline manifold 3 consisting of an inline Tee 9 with manifold module 8 and inline manifold protection cover 7, the inline manifold protection cover 7 can serve a dual purpose as a fishing and dropped object protection as well as a means to collect leakage and detection by sensor if needed.

The inline manifold protection cover can be used in organic fouling prevention. The manifold module 8 is shown as a compact compiler fitting 13 with integrated manifold branch valves 11, integrated stab connection 12 and a vertical down-facing connection 14 featuring hub and clamp for connection to inline Tee 9 with up-facing hub 16. The manifold module 8 is equipped with a lifting interface 19 at the center to allow connection with a manifold lifting tool 41 for subsea handling / installation and change out. The inline Tee 9 is equipped with an isolation valve 15 preventing infield flowline 4 to be flooded when connecting manifold module 8 or a cap. An integrated up-facing hub 16 is located on top of the isolation valve 15, allowing the manifold module 8 to connect with the inline Tee 9. An inline manifold mud mat 10 is shown connected to the inline Tee header 36 by clamp support 18 to provide bearing and torsion capacity and allow for the complete unit to slide on seabed. Retractable guideposts 43 are shown on each side of the up-facing hub 16 to allow guiding during manifold module 8 installation. The retractable guideposts 43 are guided by guidepost supports 32.

Fig. 6 Shows the manifold module 8 being installed onto the inline Tee 9, by a lifting tool 41 connected to the manifold module 8 via the lifting interface 19. The lifting tool is equipped with a single pad eye 40 to interface with the lifting shackle 42 and

have two of guide sleeves 39 to guide the manifold module 8 towards the up-facing hub 16 on the inline Tee 9.

Guide wires 37 with guidewire anchors 38 are installed into the guidewire anchor receptacle 34 on the retractable guideposts 43. The retractable guidepost 43 are extended when tensioning the guide wires 37.

Fig. 7 Shows the manifold module 8 landed on the inline Tee 9 up-facing hub 16. The down-facing connection 14 secures and seal the manifold module 8

Fig. 8 Shows the manifold module 8 landed on the inline Tee 9 up-facing hub 16. The retractable guideposts 43 are in retracted position.

Fig. 9 Shows an isometric view of export pipeline end manifold 5 in service, designed to connect the infield flowlines 4 to the export pipeline 6. The pipeline end manifold to be equipped with connections allowing the infield flowlines 4 to be connected. Pipeline end manifold 5 to be integrated with a mud mat 20 allowing for seabed support. A top cover 21 prevents for fishing gears, impact and allow for hydrogen sniffers to discover any leakage. The top cover 21 can be used in organic fouling prevention.

Fig. 10 Shows an isometric view of export pipeline end manifold 5, shown with four off branch connections 23. Isolation valves 22 on each branch avoiding export pipeline 6 to be flooded during connection of infield flowlines 4. All branches commingled into an appendix header 24 before vertical routed into the export pipeline 6. The export pipeline 6 is shown as a welded connection to the export pipe, planned to be welded at surface before installation. The blind end of the export pipeline 6 to be fitted with an anchor interface for either first or second end installation. A support structure 31 for the connection system shown as a structure directly connected to the piping. Mud mats 20 for seabed support directly connected to connection support structure 31.

Fig. 11 A subsea boosting unit 25 in context of hydrogen export added to the export pipeline 6 downstream the pipeline end manifold 5. An inline Tee 27 upstream export line x-over valve 26 and an inline Tee 30 downstream the export line x-over valve 26 allow the flow to be routed via the boosting unit 25 when closing the x-over valve 26. The Isolation valves 29 to be closed when removing the boosting unit 25 or when not in service. Connection system 28 allow boosting station to be connected or disconnected. The x-over

valves 26 and connection system 28 can be at surface if the boosting station is located on a jack-up, floating unit or similar.

Item table

| | |
|----|----------------------------------|
| 1 | hydrogen producer |
| 2 | Jumper/Riser |
| 3 | inline manifold |
| 4 | Infield flowlines |
| 5 | pipeline end manifold |
| 6 | export pipeline |
| 7 | inline manifold protection cover |
| 8 | manifold module |
| 9 | inline Tee |
| 10 | inline manifold mud mat |
| 11 | manifold branch valve |
| 12 | branch connection |
| 13 | compiler fitting |
| 14 | down facing connection |
| 15 | isolation valve |
| 16 | up-facing hub |
| 17 | vertical inlet |
| 18 | clamp support |
| 19 | lifting interface |
| 20 | mud mat |
| 21 | top cover |
| 22 | isolation valves |
| 23 | branch connection |
| 24 | appendix header |
| 25 | boosting unit |
| 26 | x-over valves |
| 27 | inline Tee |
| 28 | connection system |
| 29 | isolation valves |
| 30 | inline Tee |
| 31 | support structure |
| 32 | guidepost support |
| 33 | stab connection |
| 34 | guidewire anchor receptacle |
| 35 | flowline interface |
| 36 | inline Tee header |
| 37 | guide wire |
| 38 | guide wire anchor |
| 39 | guide sleeve |
| 40 | pad eye |
| 41 | manifold lifting tool |
| 42 | lifting shackle |
| 43 | retractable guideposts |

CLAIMS

1. A subsea hydrogen distribution system for transport of hydrogen comprising:
a number of hydrogen producers (1) arranged at surface or at seabed in decentralized positions relative to a subsea inline manifold (3);
5 a jumper/riser (2) connecting each hydrogen producer (1) with the subsea inline manifold (3);
the subsea inline manifold (3) comprising a manifold module (8) and an inline Tee (9), the manifold module (8) having a branch connection (12) for each jumper/riser (2), the branch connections (12) in flow
10 connection with an infield flowline (4) via a vertical up-facing hub (16) integrated in the inline Tee (9);
the infield flowline (4) connecting the subsea inline manifold (3) to a pipeline end manifold (5) or an export pipeline (6),
characterized in that the manifold module (8) comprises a compiler
15 fitting (13) formed with a vertical bore leading from an integrated or assembled down-facing connection (14) to each branch connection (12), a manifold branch valve (11) integrated with each branch connection (12), and wherein the down-facing connection (14) is arranged for connection to the vertical up-facing hub (16) of the inline
20 Tee (9), wherein the inline Tee (9) has an isolation valve (15) integrated in the vertical up-facing hub (16) in order to avoid flooding of the infield flowline (4) while connecting or disconnecting the manifold module (8).
- 25 2. The system of claim 1, wherein the manifold module (8) comprises a lifting interface (19) to allow a manifold lifting tool (41) to be fixed to the manifold module for guiding, installation and retrieval.

3. The system of claim 1 or 2, wherein the inline Tee (9) is designed with a rigid inline Tee header (36) prepared with a flowline interface (35), such as a flange or other type of connection, at one or at each end, allowing a flexible infield flowline (4) or export pipeline (6) to be connected.
4. The system of any previous claim, wherein the inline Tee (9) is equipped with retractable guideposts (43) to guide the manifold module (8) during landing and retrieval.
5. The system of any previous claim, wherein the inline Tee (9) can be installed with or without the manifold module (8) when laying out the infield flowline (4).
6. The system of claim 1, comprising:
a subsea boosting unit (25) connected to the export pipeline (6) via inline Tees (27) and (30) upstream and downstream of an x-over valve (26) allowing hydrogen flow to be routed via the boosting unit (25).
7. The system of claim 6, wherein the subsea boosting unit (25) is arranged onto a fixed or floating unit at surface, and wherein a connection system (28) allows flow to be routed to surface via risers.

PATENTKRAV

1. Undersjøisk hydrogendistribusjonssystem for transport av hydrogen omfattende:
et antall hydrogenprodusenter (1) anordnet på overflaten eller ved havbunnen i desentraliserte posisjoner i forhold til en undersjøisk inline-manifold (3);
5 en jumper/stigerør (2) som forbinder hver hydrogenprodusent (1) med den undersjøiske inline-manifolden (3);
den undersjøiske inline-manifolden (3) omfatter en manifoldmodul (8) og en inline T-stykket (9), manifoldmodulen (8) har en forgreningsforbindelse (12) for hver jumper/stigerør (2), forgreningsforbindelsene (12) i strømningsforbindelse med en strømningsledning (4) i felt via en vertikal oppover vendt hub (16) integrert i inline-T-stykket (9);
10 strømningsledning (4) forbinder den undersjøiske inline-manifolden (3) til en rørledningsendemanifold (5) eller en eksportørledning (6),
15 karakterisert ved at manifoldmodulen (8) omfatter en oppsamlings-tilpasning (13) utformet med en vertikal boring som leder fra en integrert eller sammensatt nedadvendt forbindelse (14) til hver forgreningsforbindelse (12), en manifoldgrenventil (11) integrert med hver forgreningsforbindelse (12), og hvor den nedadvendte forbindelse (14) er anordnet for tilkobling til den vertikale oppover vendte huben (16) til inline-T-stykket (9), hvor inline-T-stykket (9) har en isolasjonsventil (15) integrert i den vertikale oppover vendte huben (16) for å unngå oversvømmelse av strømningsledning (4) i felt mens manifoldmodulen (8) kobles til eller fra.
20
25
2. System ifølge krav 1, hvor manifoldmodulen (8) omfatter et løftegrensesnitt (19) for å tillate at et manifoldløfteverktøy (41) kan festes til manifoldmodulen for føring, installasjon og opphenting.

- 5 3. System ifølge krav 1 eller 2, hvor inline-T-stykket (9) er utformet med et stivt inline-T-formet strømningsrør (36) forberedt med et strømningslinje-grensesnitt (35), slik som en flens eller annen type forbindelse, ved en eller i hver ende, slik at en fleksibel strømningsledning (4) i felt eller eksportrørledning (6) kan kobles til.
- 10 4. System ifølge et hvilket som helst av de foregående krav, hvor inline-T-stykket (9) er utstyrt med uttrekkbare styrestolper (43) for å lede manifoldmodulen (8) under landing og opphenting.
- 15 5. System ifølge et hvilket som helst av de foregående krav, hvor det inline-T-stykket (9) kan installeres med eller uten manifoldmodulen (8) når strømningsledning (4) i felt legges ut.
- 20 6. System ifølge krav 1, omfattende:
en undersjøisk boostingsenhet (25) koblet til eksportrørledningen (6) via inline-T-stykker (27) og (30) oppstrøms og nedstrøms en forbindelses-ventil (26) som tillater hydrogenstrøm å rutes via boostingsenheten (25).
7. System ifølge krav 6, hvor den undersjøiske boostingsenheten (25) er anordnet på en fast eller flytende enhet ved overflaten, og hvor et tilkoblingssystem (28) tillater strømning å bli rutet til overflaten via stigerør.

FIGURES

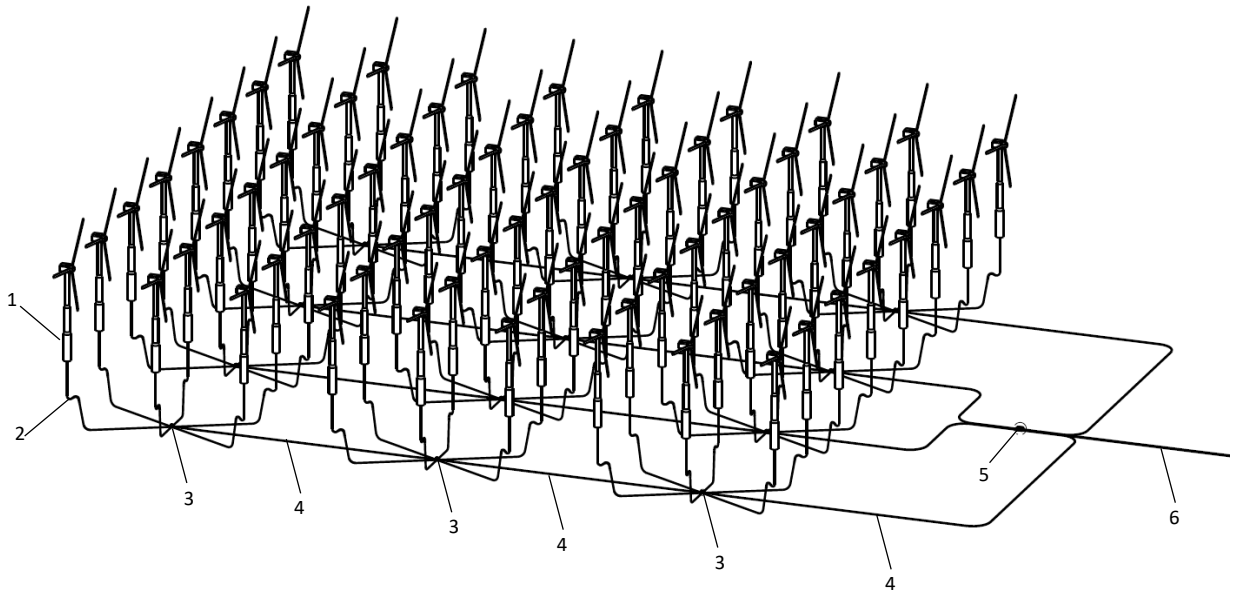


Figure 1

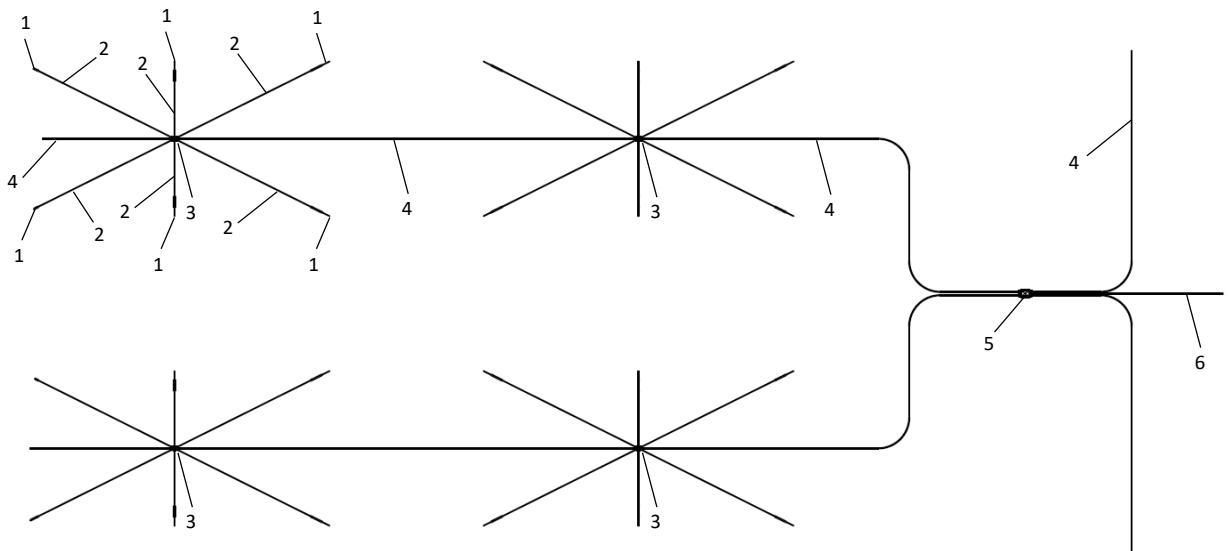


Figure 2

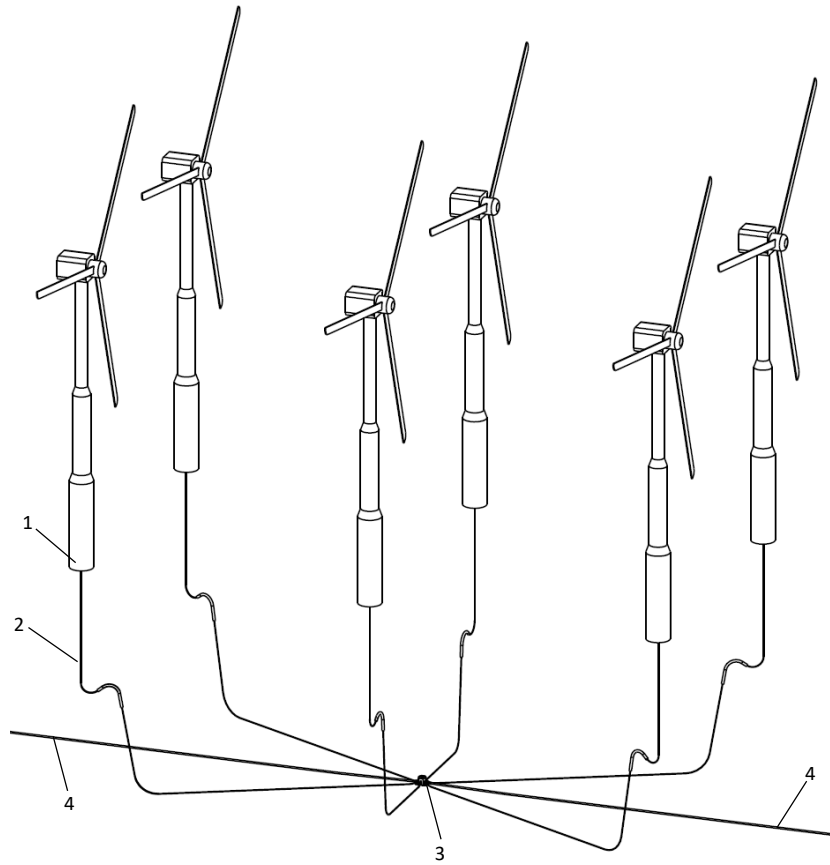


Figure 3

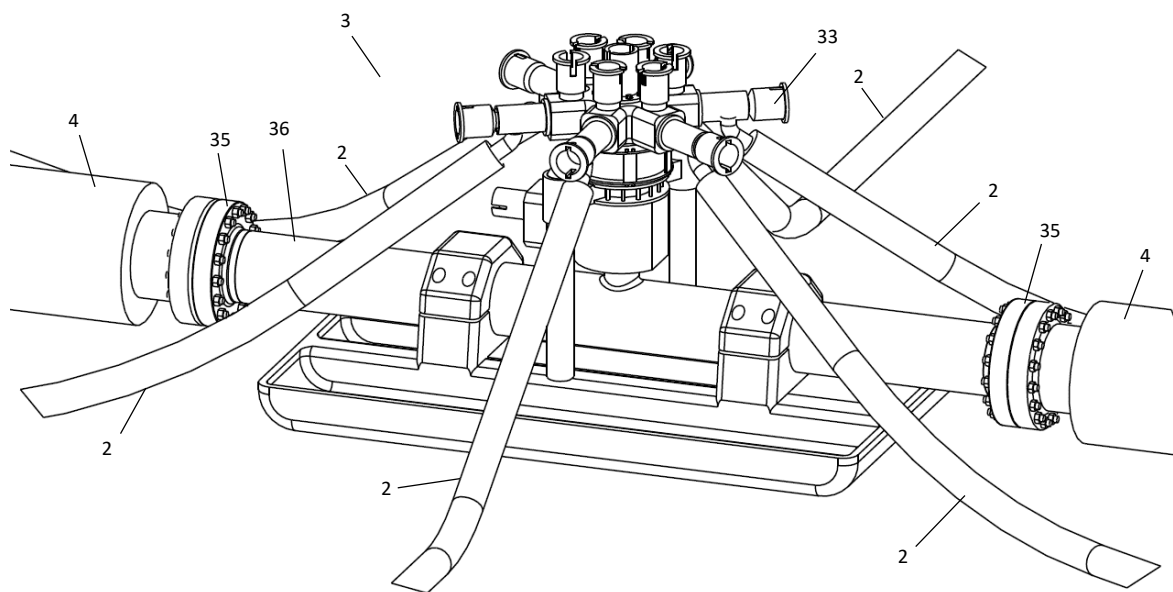


Figure 4

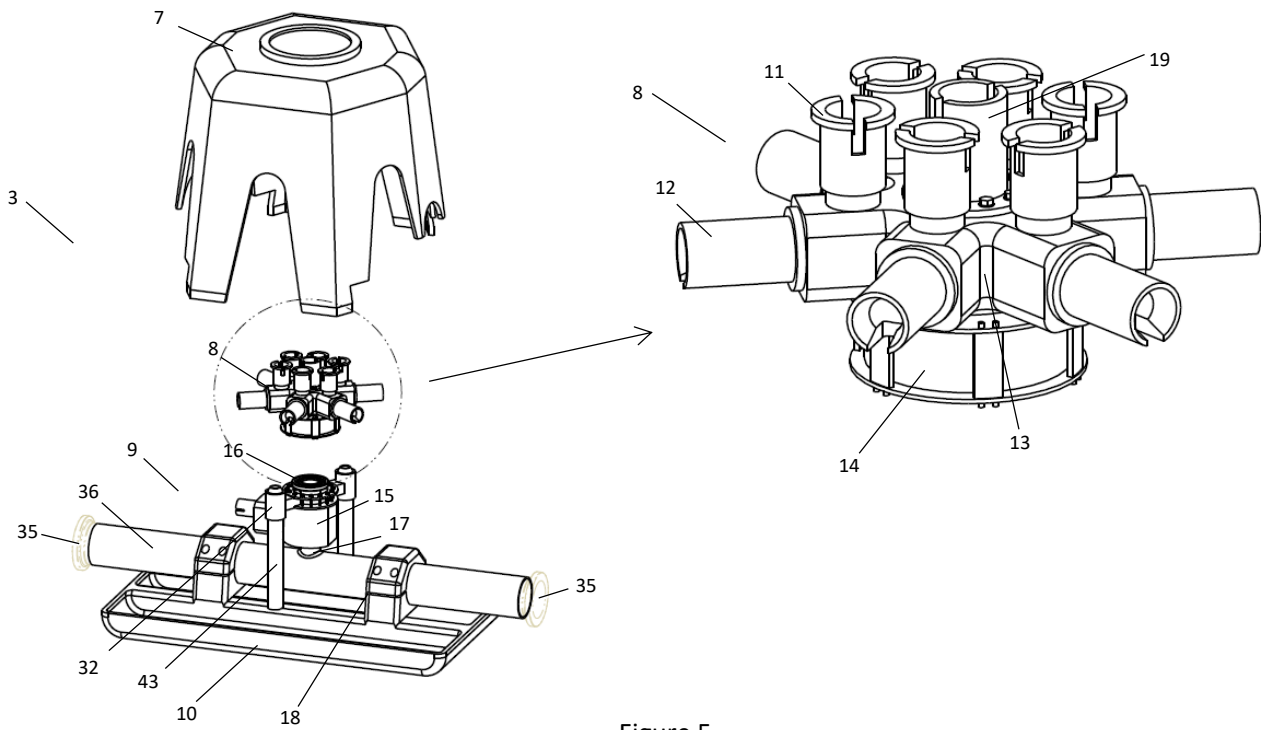


Figure 5

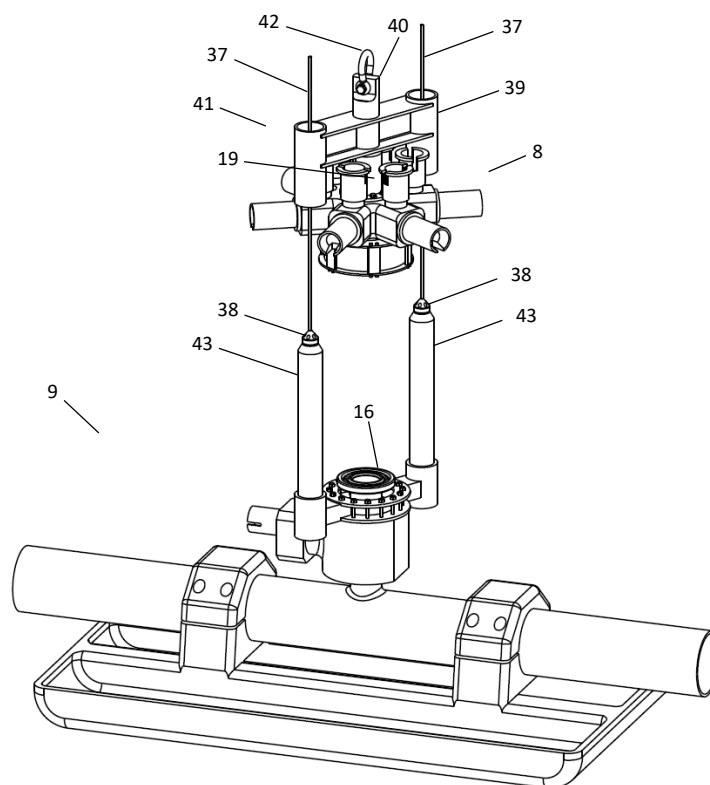


Figure 6

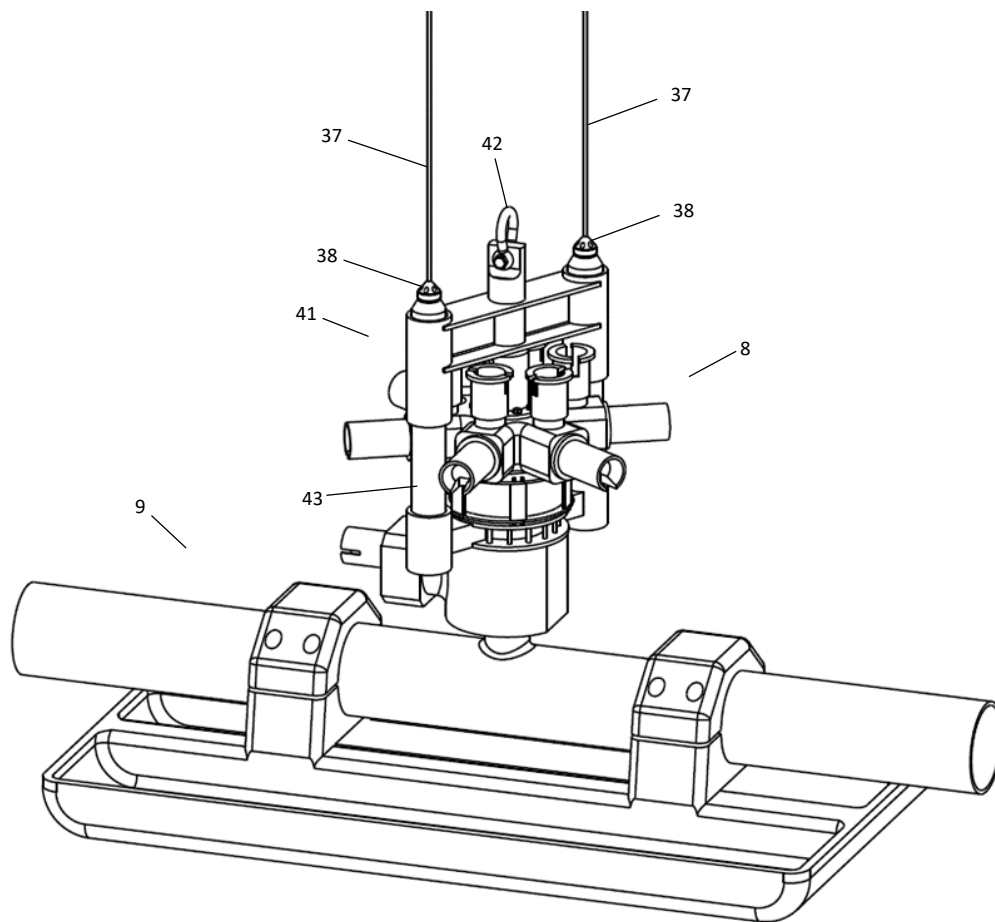


Figure 7

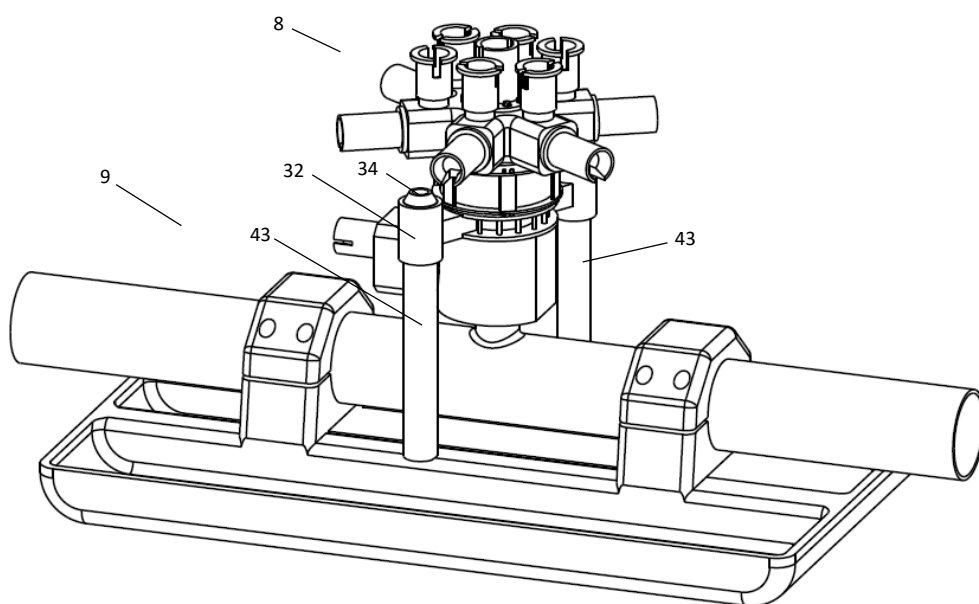


Figure 8

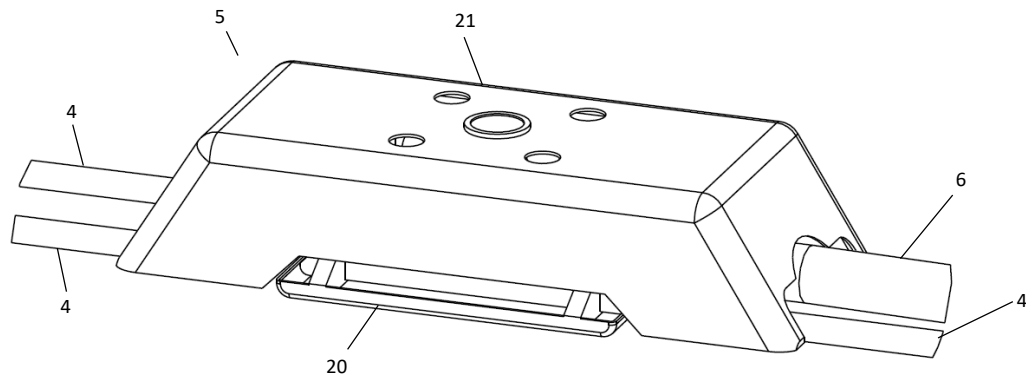


Figure 9

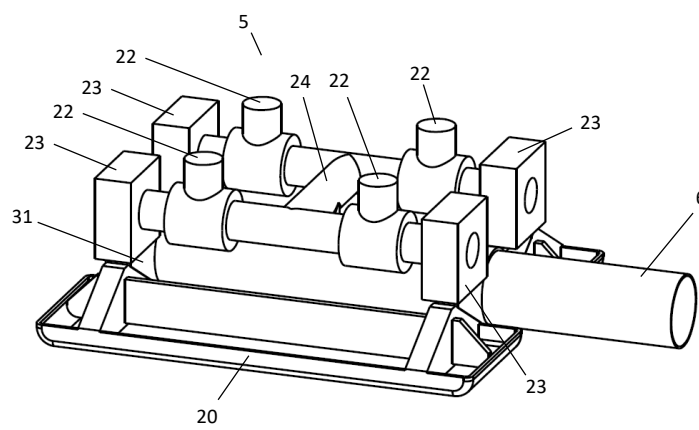


Figure 10

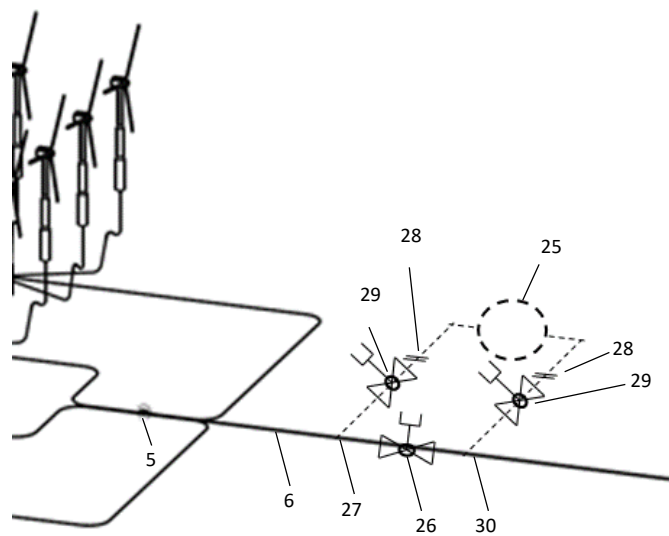


Figure 11

Item table

| | |
|----|----------------------------------|
| 1 | Hydrogen producer |
| 2 | Jumper/Riser |
| 3 | inline manifold |
| 4 | Infield flowlines |
| 5 | pipeline end manifold |
| 6 | export pipeline |
| 7 | inline manifold protection cover |
| 8 | Manifold module |
| 9 | Inline Tee |
| 10 | inline manifold mudmat |
| 11 | Manifold branch valve |
| 12 | Branch connection |
| 13 | compiler fitting |
| 14 | Down facing connection |
| 15 | isolation valve |
| 16 | up-facing hub |
| 17 | vertical inlet |
| 18 | Clamp support |
| 19 | lifting interface |
| 20 | Mud mat |
| 21 | Top cover |
| 22 | Isolation valves |
| 23 | branch connection |
| 24 | appendix header |
| 25 | boosting unit |
| 26 | x-over valves |
| 27 | inline Tee |
| 28 | connection system |
| 29 | Isolation valves |
| 30 | inline Tee |
| 31 | support structure |
| 32 | Guidepost support |
| 33 | Stab connection |
| 34 | Guidewire anchor receptacle |
| 35 | Flowline interface |
| 36 | Inline Tee header |
| 37 | Guide wire |
| 38 | Guide wire anchor |
| 39 | Guide sleeve |
| 40 | Pad eye |
| 41 | Manifold lifting tool |
| 42 | Lifting shackle |
| 43 | Retractable guideposts |