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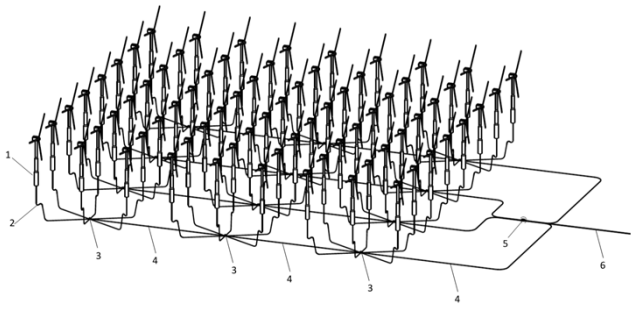
(54) Title **Subsea hydrogen distribution from decentralized producers**

(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 application relates to a field configuration or layout of a pipeline system consisting of infield flowline 4 and export pipeline 6 in connection with a subsea inline manifold 3 utilized in connection with a decentralized hydrogen producer 1 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 1, typical in the context of a wind power farm, solar power, or wave/tidewater power farms.

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 typical 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 remote 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.

Short description of the drawings:

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

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

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

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

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

Fig. 6 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

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

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

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

Fig. 10 isometric view of a hydrogen export pipeline end manifold module 5

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

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 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 mean 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 mudmat 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 mudmat 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.

CLAIMS

1. A subsea hydrogen distribution system for transport of hydrogen comprising;
   a decentralized hydrogen producer 1 at surface or at the seabed;

a jumpers/riser 2 between hydrogen producer 1 and an inline manifold 3;
a subsea inline manifold 3 consisting of a manifold module 8 and an inline Tee 9, manifold module with two or more branch connection 12 that is direct connected to an infield flowline 4 via the vertical up-facing hub 16 integrated in the inline Tee 9;
at least one infield flowline 4 connecting inline manifold 3 to a pipeline end manifold 5 or an export pipeline 6;

2. The manifold module 8, of claim 1, were the manifold module 8 is made by a compiler fitting 13 with integrated or assembled down-facing connection 14, manifold branch valve 11 and branch connection 12.
3. The manifold module 8, of claim 1, were the manifold module 8 includes a lifting interface 19 to allow a manifold lifting tool 41 to be fixed to the manifold module for guiding, installation and retrieval.
4. The inline Tee 9, of claim 1, wherein the inline Tee 9 includes an isolation valve 15 with an integrated vertical up-facing hub 16, in order to avoid flooding of the infield flowline 4 while connecting or disconnecting the manifold module 8.
5. The inline Tee 9, of claim 1, wherein the inline Tee 9 is designed with a rigid inline Tee header 36 prepared with a flowline interface 35 typically a flange or other type of connection at one or each end, allowing a flexible infield flowline 4 or export pipeline 6 to be connected.
6. The inline Tee 9, of claim 1, wherein the inline Tee 9 is equipped with retractable guideposts 43 to guide manifold module 8 during landing and retrieval.
7. The inline manifold 3, of claim 1, wherein the inline Tee 9 can be installed with or without the manifold module 8 when laying out the infield flowline 4.
8. The inline manifold 3, of claim 1, wherein the inline manifold 3 is used for any subsea hydrocarbon production or CO2, water or service injection.
9. The subsea hydrogen distribution system field layout, of claim 1,
a subsea boosting unit 25, connected to the export pipeline 6 via inline Tee's 27 and 30 up and downstream the x-over valve 26 allow hydrogen flow to be routed via the boosting unit 25.
10. The subsea boosting unit 25, of claim 9, wherein the subsea boosting unit 25 is moved to surface onto a fixed or floating unit;
risers to be connected to connection system 28 allowing flow to be routed to surface.

FIGURES

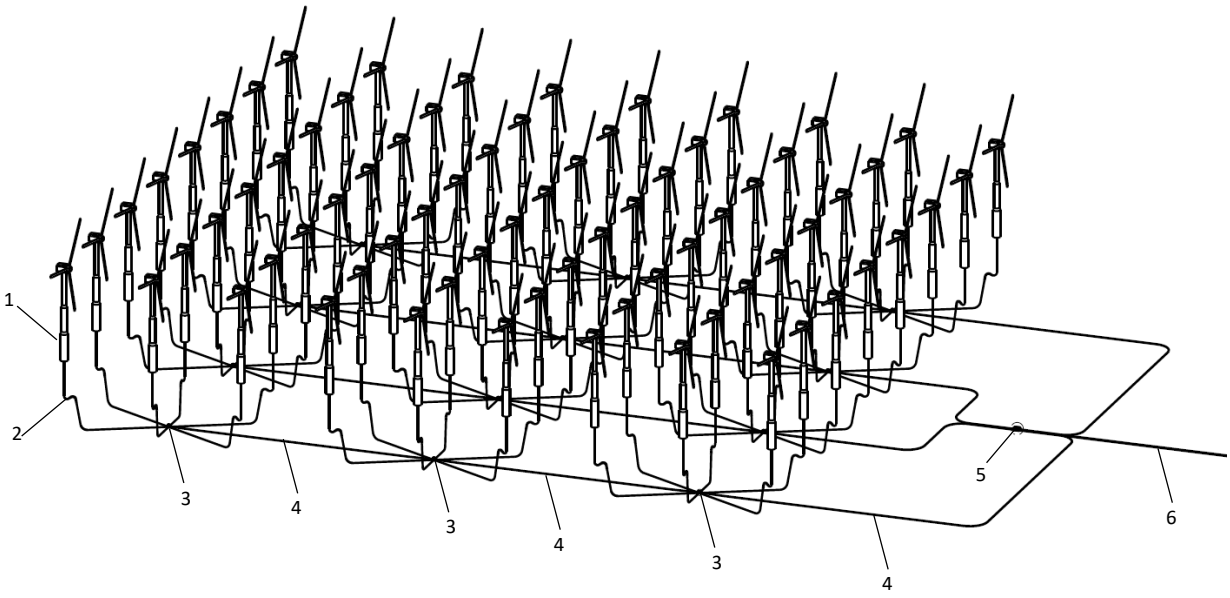


Figure 1

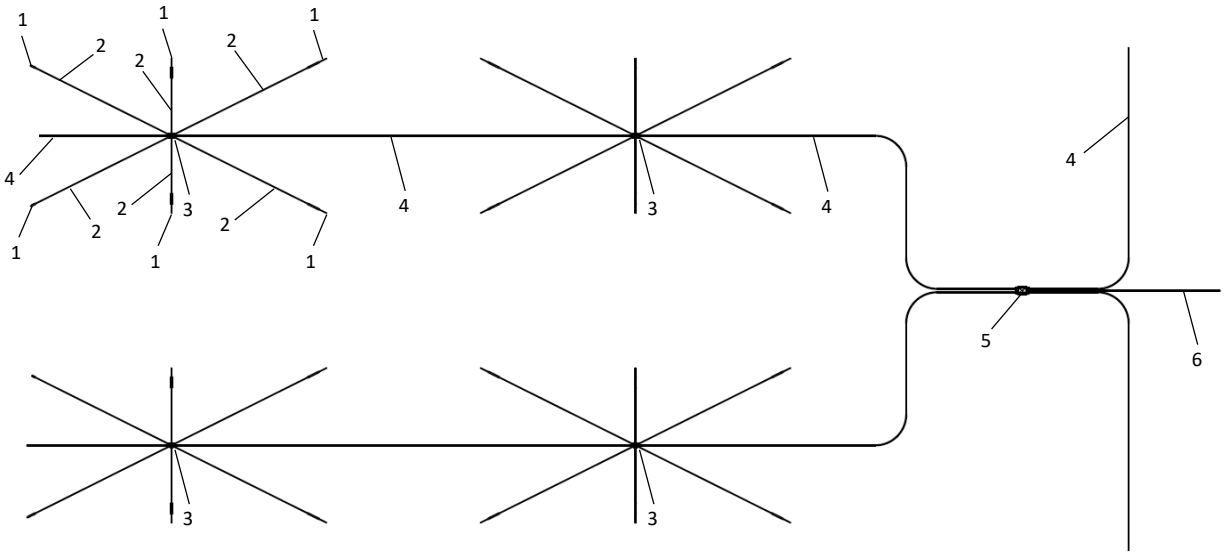


Figure 2

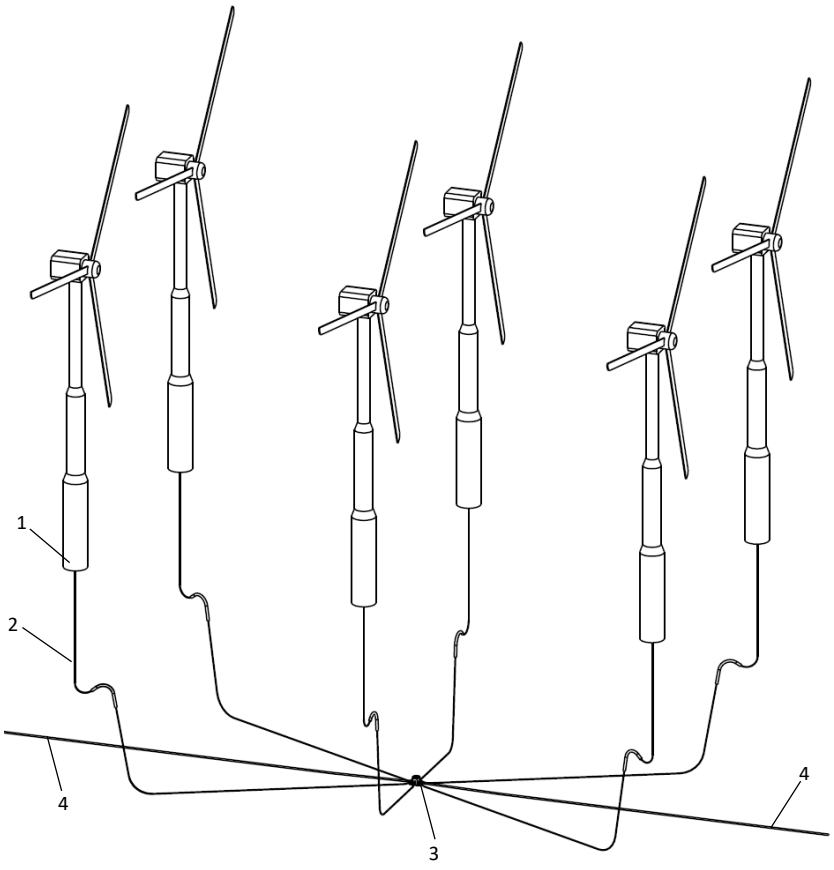


Figure 3

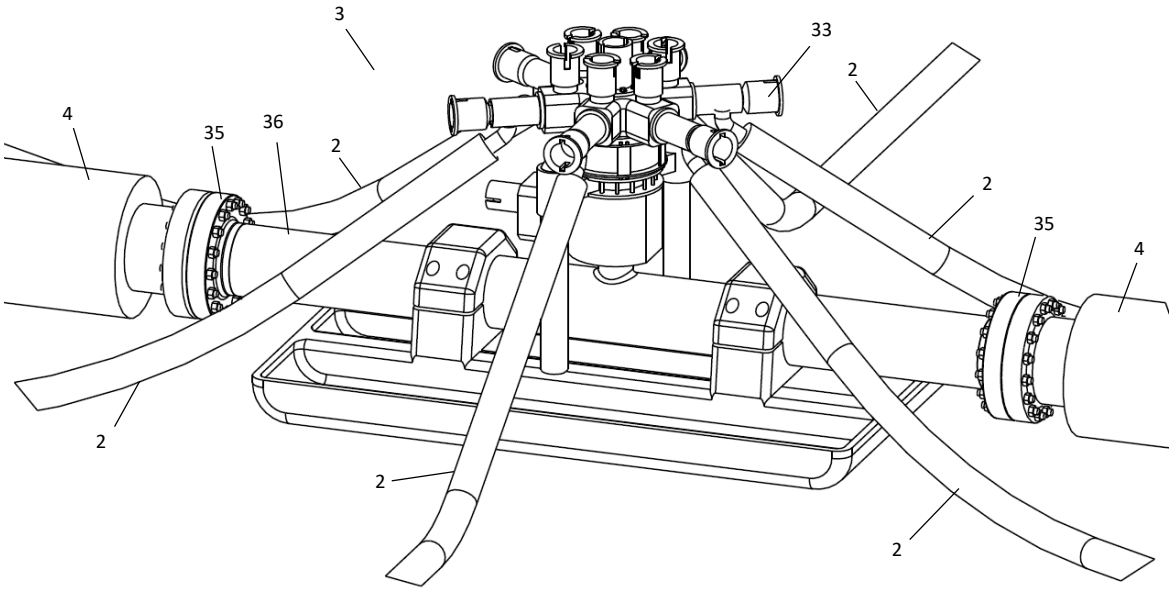


Figure 4

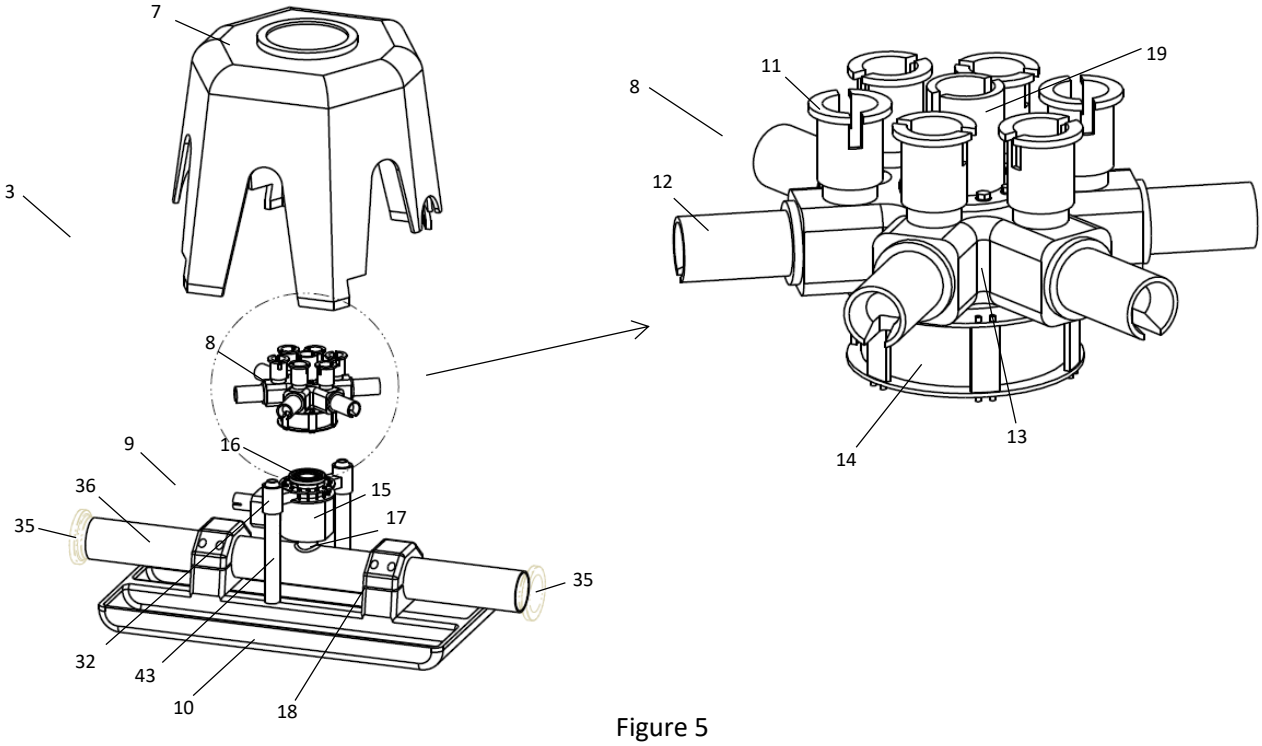


Figure 5

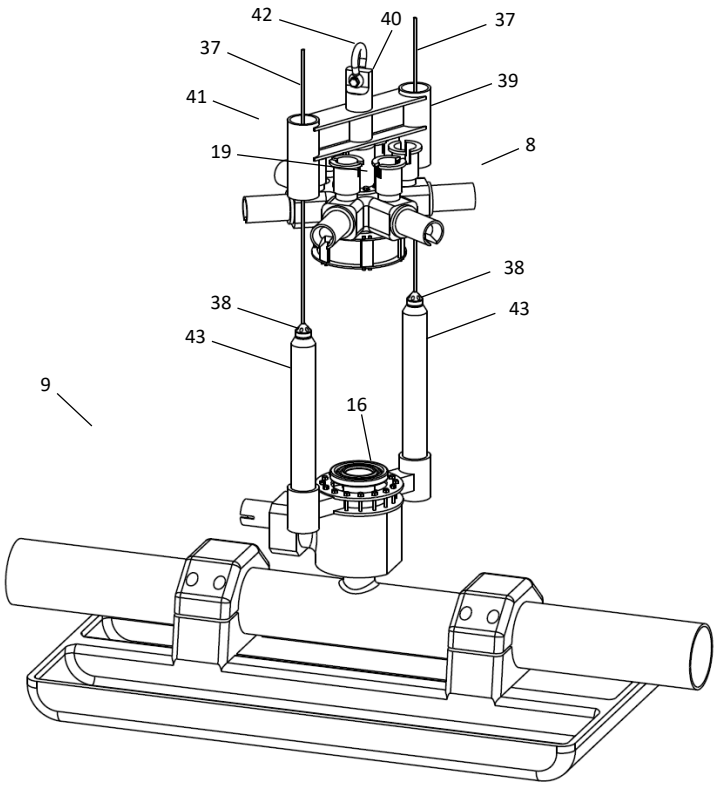


Figure 6

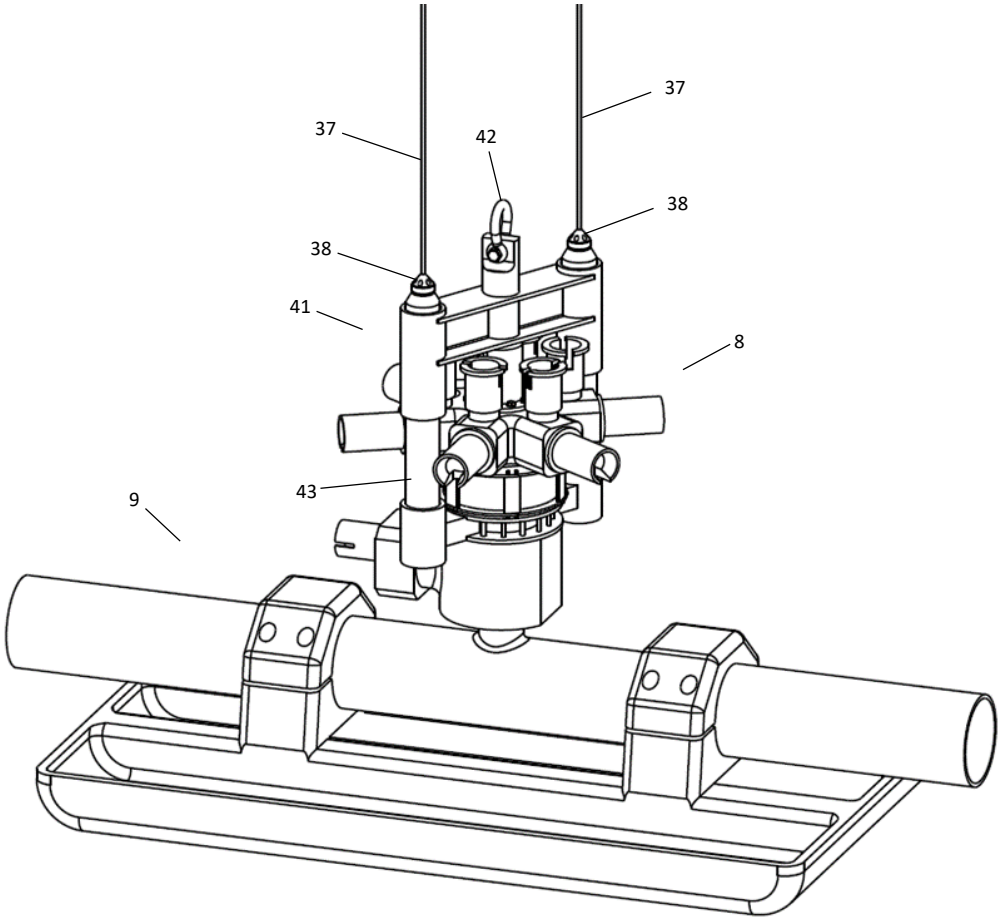


Figure 7

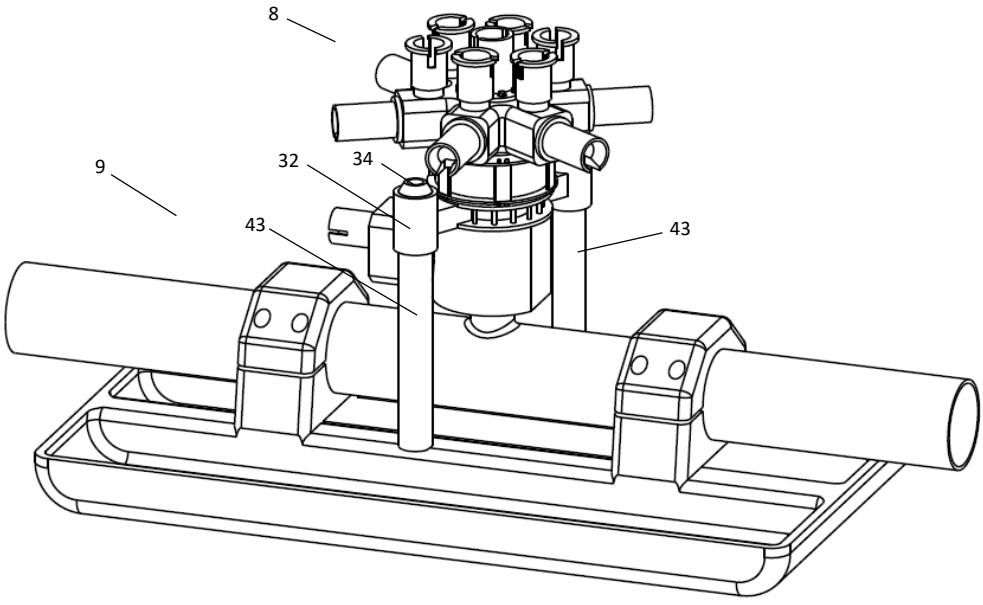


Figure 8

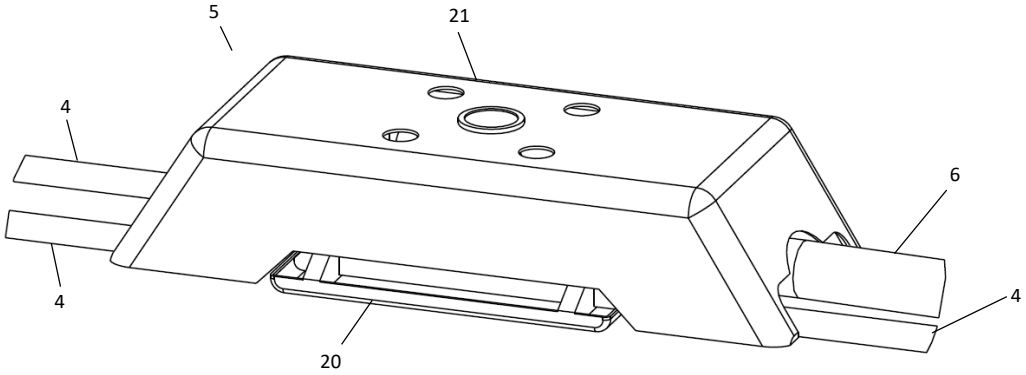


Figure 9

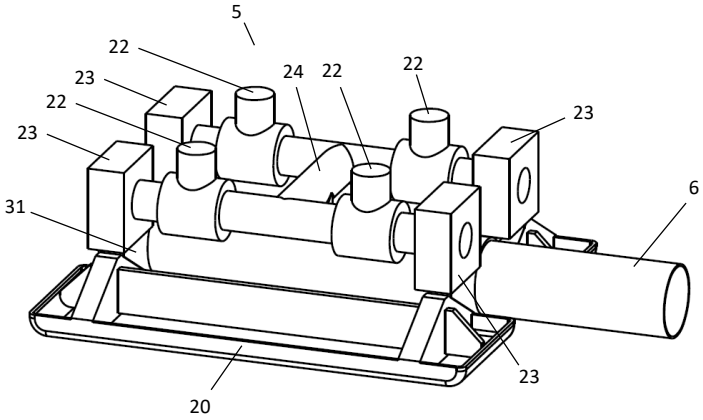


Figure 10

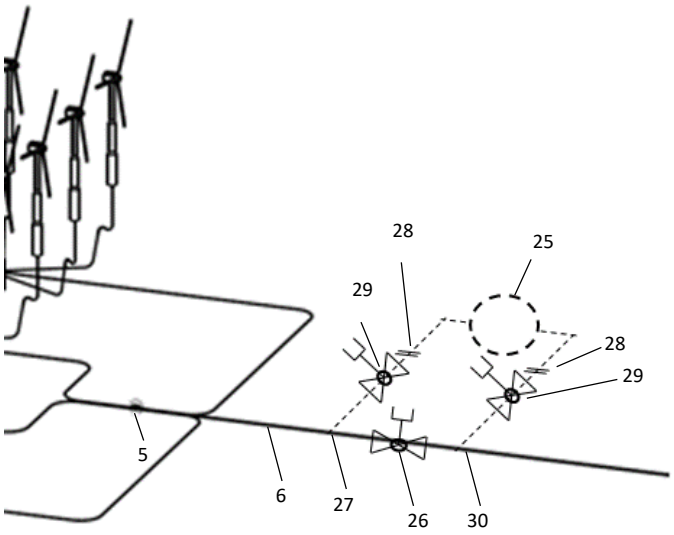


Figure 11

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