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(54) **OPEN WATER COILED TUBING CONTROL SYSTEM**

SYSTEM ZUR STEUERUNG EINES GEWICKELTEN ROHRSTRANGES IN OFFENEN GEWÄSSERN

SYSTÈME DE COMMANDE DE TUBULURE ENROULÉE EN EAU LIBRE

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Description

RELATION TO OTHER APPLICATIONS

[0001] This application claims priority through United States Provisional Application 62/924,045 filed on October 21, 2019.

BACKGROUND

[0002] Running coiled tubing (CT) in open water from a vessel, and then possibly directly through a subsea tree, as well as running CT by utilizing an injector on a vessel and an injector on the subsea tree/wellhead typically comprises concerns with maintenance of tension between vessel injector and subsea injector and/or reliance of passive heave control for the vessel injector. A direct hydraulic control system, e.g. a vessel to subsea assist jack, is impractical as the whip effect stress wave travels at near the speed of sound in the coiled tubing steel (damped by the surrounding water) whereas the transmission of a hydraulic pressure change command travels at the speed of sound in the hydraulic fluid. The former is approximately four times faster than the later.

[0003] Existing systems do not disclose or render obvious an integrated control system that responds to a single operator input and controls.

[0004] Prior art document U.S. 2015/101799 A1 discloses methods and apparatus for monitoring loads on an arched tubing guide of a coiled tubing injector caused by tension on coiled tubing. The load is sensed by a load sensor, for example, a load cell placed in a strut that supports the arched tubing guide, or in a load pin or load cell placed within the structure arched tubing guide or the connection of the arched tubing guide to a frame for the coiled tubing injector, at a location where the load is representative of the load placed on an arched tubing guide by tension in the coiled tubing. The load sensor generates a feedback signal. The load is monitored, either by an operator or a controller, and torque applied to a reel around which the tubing is wound is adjusted to avoid, or in response to, excessive loads on the arched tubing guide.

[0005] Prior art document U.S. 2018/080850 A1 discloses a technique that facilitates monitoring and managing fatigue related a flexible conduit deployed from a surface vessel. Movements of the surface vessel may be measured to obtain vessel movement/position data. Based on this data, a flexible conduit bend profile may be determined via a computer-based data processing system. The flexible conduit bend profile may then be used to provide a flexible conduit fatigue profile for assessment of the flexible conduit in light of the environmental conditions. In some embodiments, the fatigue profile and assessment of the flexible conduit may be based on both functional loading and environmental loading.

[0006] Prior art document U.S. 5,975,203 A discloses an apparatus and method for pulling or inserting jointed pipe sections having upset ends within a well utilizing a coiled tubing injector. The coiled tubing injector has a pair of opposed endless chains including gripper blocks for gripping the pipe sections. An axial gap is provided in chains between adjacent gripper blocks to receive the upset ends. To align accurately upset ends with gap, a sensing mechanism is provided to sense the location of upset end and a sensing mechanism is provided to sense the location of gap. An operator in response to signals from the sensors accurately aligns upset ends with gap.

[0007] Prior art document U.S. 2004/065475 A1 discloses an apparatus and method for offshore riserless drilling. The preferred embodiments comprise a system for riserless drilling of a subsea borehole from a platform and through a cased borehole, the system comprising a lightweight drill string suspending a bottomhole assembly and extending from the platform downwardly through a depth of water into the cased borehole; a first limiter limiting the range of motion of the drill string adjacent the platform; and a second limiter limiting the range of motion of the drill string adjacent the cased borehole. The preferred methods include lowering a bottomhole assembly suspended on a lightweight drill string from a platform through a depth of water; limiting the bend radius of the drill string adjacent the platform; guiding the bottomhole assembly into a cased borehole; limiting the bend radius of the drill string adjacent the cased borehole; maintaining the bottomhole assembly in the cased borehole, and drilling the subsea borehole.

[0008] Prior art document U.S. 2002/029908 A1 discloses a downhole drilling tractor for moving within a borehole comprises a tractor body, two packerfeet, two aft propulsion cylinders, and two forward propulsion cylinders. The body comprises aft and forward shafts and a central control assembly. The packerfeet and propulsion cylinders are slidably engaged with the tractor body. Drilling fluid can be delivered to the packerfeet to cause the packerfeet to grip onto the borehole wall. Drilling fluid can be delivered to the propulsion cylinders to selectively provide downhole or uphole hydraulic thrust to the tractor body. The tractor receives drilling fluid from a drill string extending to the surface. A system of spool valves in the control assembly controls the distribution of drilling fluid to the packerfeet and cylinders. The valve positions are controlled by motors. A programmable electronic logic component on the tractor receives control signals from the surface and feedback signals from various sensors on the tool. The feedback signals may include pressure, position, and load signals. The logic component also generates and transmits command signals to the motors, to electronically sequence the valves. Advantageously, the logic component operates according to a control algorithm for intelligently sequencing the valves to control the speed, thrust, and direction of the tractor.

[0009] Prior art document U.S. 2004/040707 A1 discloses an apparatus and methods for sequentially treating multiple zones in underground formation in a single

trip of the well treatment work string. In the one embodiment, the work string includes composite tubing having electrical conductors embedded within the walls, the conductors enabling power transmission and two way communication between the surface and the sensor or detectors downhole so that real time data can be sensed and communicated. Isolation packers are actuated via electrical signals from the surface communicated to the bottom hole assembly via the conductors. A detector located in the bottom hole assembly may be provided to detect perforations or other anomalies in the casing, such as joints, enabling the surface controller to position packers properly in blank segments of casing so that well intervals can be properly isolated and the adjacent formation effectively treated.

[0010] Prior art document U.S. 7,530,399 A1 discloses a delivery system for downhole use comprising an elongate delivery member, such as a length of wireline cable or coiled tubing, an injector to control the insertion of the delivery member into the well, and a storage device such as a reel to store at least a portion of the delivery member prior to insertion into the well. The system has a motion compensator arranged to compensate for relative motion between the injector and the storage device. The motion compensator optionally is arranged to compensate for relative movement between the injector and the well, and the movement of the motion compensator on the storage device and the motion compensator on the injection head can be coordinated by a motion controller adapted and arranged to measure the movement of the injector and to signal the motion compensator on the storage device to move in accordance with the movement of the injector.

[0011] Prior art document U.S. 2016/369614 A1 discloses a coiled tubing deployment system which includes an offshore rig having a reel positioned thereon and coiled tubing wound on the reel. A guide arch receives the coiled tubing from the reel and a monitoring support guide fixed to the offshore rig receives and directs the coiled tubing into water. The monitoring support guide has a frame and at least two hydraulic rams. A depth counter measures the coiled tubing deployed from the reel and generates length measurement signals, and sensors coupled to the at least two hydraulic rams measure real-time lateral movement of the coiled tubing with respect to the monitoring support guide as the coiled tubing is deployed into the water and thereby generate sensor signals. A data acquisition system receives and processes the length measurement and sensor signals to provide an output signal indicative of real-time bending fatigue of the coiled tubing at select locations along the coiled tubing.

[0012] Prior art document U.S. 6,116,345 discloses a tubing injection system that contains one injector for moving a tubing from a source thereof to a second injector. The second injector moves the tubing into the wellbore. In an alternative embodiment for subsea operations, the system may contain a first injector placed under water over the wellhead equipment for moving the tubing to and from the wellbore. A second injector at the surface moves the tubing to the first injector and a third injector moves the tubing from the tubing source to the second injector. In each of the tubing injection systems sensors are provided to determine the radial force on the tubing exerted by the injectors, tubing speed, injector speed, and the back tension on the source. A control unit containing a computer continually maintains the tubing speed, tension and radial pressure on the tubing within predetermined limits. The control unit is programmed to automatically control the operation of the tubing injection systems according to programs or models provided to the control unit.

FIGURES

[0013] Various figures are included herein which illustrate aspects of embodiments of the disclosed inventions.

[0014] **Fig. 1** is a block diagram of an exemplary open water coiled tubing control system.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0015] In a first embodiment, referring generally to **Fig. 1,** open water coiled tubing control system I comprises reel 20 configured to accept and spool/unspool coiled tubing string 100; one or more surface injectors 30 operatively in fluid communication with coiled tubing string 100; one or more reel tensioners 10 configured to control arch 110 formed by coiled tubing string 100 where control arch 110 is disposed in-between reel 20 and surface injector 30; and one or more controllers 40 configured to control reel tensioner 10 and allow movement of coiled tubing string 100 and surface injector 30 relative to each other without adding additional fatigue life consumption due to vessel heave.

[0016] Open water coiled tubing control system 1 typically uses surface injector motion to move coiled tubing string 100 into/out of the water.

[0017] Typically, coiled tubing string 100 is disposed about an outer surface of reel 20 but other embodiments are contemplated such as being disposed within or partially within reel 20.

[0018] Surface injector 30 may be mounted on heave compensator 32.

[0019] In embodiments, controller 40 is disposed intermediate reel 20 and surface injector 30 above a water level such as by being connected to, or otherwise mounted on or to, vessel 210.

[0020] In certain embodiments, open water coiled tubing control system 1 further comprises subsea assist jack 50 to move coiled tubing string 100 into/out of subsea well 200.

[0021] In most embodiments, open water coiled tubing control system 1 comprises a predetermined set of sensors (generally referred to but not specifically shown in the figure as callout "60"), which may be integrated into

other components or separate. Typically, the predetermined set of sensors 60 are operatively in communication with controller 40 and comprises one or more surface injector load sensors 61 configured to detect and provide data related to a load at surface injector 30; one or more coiled tubing string movement sensors 62 configured to detect and provide data related to movement of coiled tubing string 100 in reel tensioner 10 where the data comprise speed of movement; one or more surface injector movement sensors 63 configured to detect and provide data related to movement of surface injector 30; and one or more vessel movement sensors 64 configured to detect and provide data related to movement of vessel 210 where the data comprise active heave data and/or passive heave data. In embodiments comprising subsea assist jack 50, the predetermined set of sensors 60 typically also comprise one or more subsea assist jack load sensors 65 configured to detect and provide data related to a load at subsea assist jack 50 and one or more subsea assist jack movement sensors 66 configured to detect and provide data related to movement of subsea assist jack 50.

[0022] In the operation of exemplary methods, referring back to **Fig. 1,** in an embodiment, open water coiled tubing control system 1 is deployed such as via vessel 210 which may also used to support surface injector 30. Open water coiled tubing control system 1 receives information related to a load at surface injector 30 and, if present, at subsea assist jack 50; information on movement of coiled tubing string 100 in reel tensioner 10, surface injector 30, and, if present, subsea assist jack 50; and information on movement of vessel 210 or a compensation system such as heave compensator 32 used to support surface injector 30, e.g. either active or passive heave.

[0023] Open water coiled tubing control system 1 resolves all or a predetermined part of the information so received, e.g. by controller 40, to effect movement of coiled tubing string 100 into and/or out from subsea well 200 at a predetermined desired speed to achieve an outcome by having one or more commands issued to reel tensioners 10 by a single input from an operator. Typically, this is accomplished by an operator using controller 40 to issue one or more commands to reel 20, surface injectors 30, and reel tensioners 10 substantially simultaneously.

[0024] In currently contemplated methods, part of the resolved solution is to maintain coiled tubing string 100 at a predetermined tension in-between surface injector 30 and subsea assist jack 50. Typically, controller 40 uses the information it receives from sensors 60 and determines a continuous movement rate of surface injector 30 versus an interrupted rate of subsea assist jack 50.

[0025] In certain embodiments, subsea assist jack 50 can be remotely disengaged from gripping coiled tubing string 100 when the force supplied by subsea assist jack 50 is no longer required to move coiled tubing string 100 into or out of subsea well 200. This can be accomplished by traditional means and/or by an instruction provided to controller 40 from a remote location or the like.

[0026] Open water coiled tubing control system l typically needs to have limited hysteresis to avoid a "whip effect" caused in part by an induced vessel movement resulting from wave action. Knowledge of the "whip effect" and the speed of translation on the stress wave through coiled tubing string 100 allows a determination of required system performance and operating limits of open water coiled tubing control system 1 versus the "sea state."

[0027] The foregoing disclosure and description of the inventions are illustrative and explanatory. Various changes in the size, shape, and materials, as well as in the details of the illustrative construction and/or an illustrative method may be made without departing from the scope of the claims.

Claims

1. An open water coiled tubing control system (1), comprising:

    a. a reel (20) configured to accept a coiled tubing string (100);
    b. a surface injector (30) in fluid communication with the coiled tubing string;
    c. a reel tensioner (10) configured to control an arch (110) formed by the coiled tubing string between the reel and the surface injector;
    d. a subsea assist jack (50) configured to move the coiled tubing string into or out of a subsea well (200);
    e. a predetermined set of sensors (60) comprising:

        i. a surface injector load sensor (61) configured to detect and provide data related to a load at the surface injector;
        ii. a coiled tubing string movement sensor (62) configured to detect and provide data related to movement of the coiled tubing string in the reel tensioner, the data comprising speed of movement;
        iii. a surface injector movement sensor (63) configured to detect and provide data related to movement of the surface injector;
        iv. a vessel movement sensor (64) configured to detect and provide data related to movement of a vessel (210), the data comprising active heave data or passive heave data;
        v. a subsea assist jack load sensor (65) configured to detect and provide data related to a load at the subsea assist jack; and
        vi. a subsea assist jack movement sensor (66) configured to detect and provide data

related to movement of the subsea assist jack; and

f. a controller (40) operatively in communication with the predetermined set of sensors (60), the controller configured to use information it receives from the predetermined set of sensors (60) to maintain the coiled tubing string (100) at a predetermined tension by determining a continuous movement rate of the surface injector (30) versus an interrupted rate of the subsea assist jack (50).

2. The open water coiled tubing control system of Claim 1, wherein the reel is configured to accept the coiled tubing string about an outer surface of the reel and/or to accept the coiled tubing string partially within the reel.

3. The open water coiled tubing control system of Claim 1, wherein the controller (40) is disposed intermediate the reel (20) and the surface injector (30).

4. The open water coiled tubing control system of Claim 1, wherein the controller (40) is connected or otherwise mounted to [[a]] the vessel (210).

5. The open water coiled tubing control system of Claim 1, wherein the subsea assist jack (50) is deployed into the water from the vessel.

6. A method moving a coiled tubing string into and/or out from water, comprising:

a. deploying an open water coiled tubing control system (1) at sea with a vessel, the open water coiled tubing control system (1), comprising a reel (20) configured to accept a coiled tubing string (100), a surface injector (30) in fluid communication with the coiled tubing string and supported by the vessel, a reel tensioner (10) configured to control an arch (110) formed by the coiled tubing string between the reel and the surface injector, a subsea assist jack (50) configured to move the coiled tubing string into or out of a subsea well, a predetermined set of sensors (60) comprising a load sensor configured to detect and provide data related to a load at the surface injector, a coiled tubing string movement sensor configured to detect and provide data related to movement of the coiled tubing string in the reel tensioner, the data comprising speed of movement, a surface injector movement sensor configured to detect and provide data related to movement of the surface injector, a vessel movement sensor configured to detect and provide data related to movement of the vessel where the data comprise active heave data or passive heave data, a subsea assist jack load sensor configured to detect and provide data related to a load at the subsea assist jack, and a subsea assist jack movement sensor configured to detect and provide data related to movement of the subsea assist jack, and a controller (40) operatively in communication with the predetermined set of sensors (60), the controller configured to maintain the coiled tubing string (100) at a predetermined tension by using information it receives from the predetermined set of sensors (60) to determine a continuous movement rate of the surface injector (30) versus an interrupted rate of the subsea assist jack (50);

b. using motion of the surface injector and the subsea assist jack to move a coiled tubing string accepted by the reel into and/or out of a subsea well (200) by:

i. receiving information at the controller from the predetermined set of sensors representing a load at the surface injector and at the subsea assist jack;

ii. receiving information at the controller from the predetermined set of sensors on movement of the coiled tubing string in the reel tensioner, the surface injector, and the subsea assist jack;

iii. receiving information at the controller from the predetermined set of sensors on movement of the vessel used to support the surface injector;

iv. using the controller to resolve the received information to move the coiled tubing string into or out from the subsea well at a predetermined desired speed to achieve an outcome commanded by a single input from an operator, the single input from the operator comprising a command sent to the reel, the surface injector, and the reel tensioner substantially simultaneously.

7. The method moving a coiled tubing string into and/or out of water of Claim 6, wherein maintaining the coiled tubing string in a predetermined tension between the surface injector and the subsea assist jack further comprises controlling the reel tensioner to allow movement of the coiled tubing string and the surface injector relative to each other without adding additional fatigue life consumption due to vessel heave.

8. The method moving a coiled tubing string into and/or out of water of Claim 6, further comprising using the controller to determine a continuous movement rate of the surface injector versus an interrupted rate of the subsea assist jack.

9. The method moving a coiled tubing string into and/or out of water of Claim 6, further comprising remotely disengaging the subsea assist jack from gripping the coiled tubing string when a force supplied by the subsea assist jack is no longer required to move the coiled tubing string into or out of the subsea well.

Patentansprüche

1. Freiwasser-Wickelrohr-Steuersystem (1), umfassend:

a. eine Spule (20), die dazu konfiguriert ist, einen Wickelrohrstrang (100) aufzunehmen;
b. einen Oberflächeninjektor (30) in Fluidverbindung mit dem Wickelrohrstrang;
c. eine Spulenspannvorrichtung (10), die dazu konfiguriert ist, eine von dem Wickelrohrstrang zwischen der Spule und dem Oberflächeninjektor gebildete Bogenform (110) zu steuern;
d. eine Untersee-Hilfshebevorrichtung (50), die dazu konfiguriert ist, den Wickelrohrstrang in eine oder aus einem Unterseebohrloch (200) zu bewegen;
e. einen vorgegebenen Satz von Sensoren (60), umfassend:

i. einen Oberflächeninjektor-Lastsensor (61), der dazu konfiguriert ist, mit einer Last an dem Oberflächeninjektor zusammenhängende Daten zu erfassen und bereitzustellen;
ii. einen Wickelrohrstrang-Bewegungssensor (62), der dazu konfiguriert ist, mit Bewegung des Wickelrohrstrangs in der Spulenspannvorrichtung zusammenhängende Daten zu erfassen und bereitzustellen, wobei die Daten die Bewegungsgeschwindigkeit umfassen;
iii. einen Oberflächeninjektor-Bewegungssensor (63), der dazu konfiguriert ist, mit Bewegung des Oberflächeninjektors zusammenhängende Daten zu erfassen und bereitzustellen;
iv. einen Schiffsbewegungssensor (64), der dazu konfiguriert ist, mit Bewegung eines Schiffs (210) zusammenhängende Daten zu erfassen und bereitzustellen, wobei die Daten Daten zu aktiver Tauchbewegung oder Daten zu passiver Tauchbewegung umfassen;
v. einen Untersee-Hilfshebevorrichtungs-Lastsensor (65), der dazu konfiguriert ist, mit einer Last an der Untersee-Hilfshebevorrichtung zusammenhängende Daten zu erfassen und bereitzustellen; und
vi. einen Untersee-Hilfshebevorrichtungs-Bewegungssensor (66), der dazu konfiguriert ist, mit Bewegung der Untersee-Hilfshebevorrichtung zusammenhängende Daten zu erfassen und bereitzustellen; und

f. eine Steuereinheit (40) in Wirkverbindung mit dem vorgegebenen Satz von Sensoren (60), wobei die Steuereinheit dazu konfiguriert ist, Informationen, die sie von dem vorgegebenen Satz von Sensoren (60) empfängt, zu verwenden, um den Wickelrohrstrang (100) durch Bestimmen einer kontinuierlichen Bewegungsrate des Oberflächeninjektors (30) gegenüber einer unterbrochenen Rate der Untersee-Hilfshebevorrichtung (50) auf einer vorgegebenen Spannung zu halten.

2. Freiwasser-Wickelrohr-Steuersystem nach Anspruch 1, wobei die Spule dazu konfiguriert ist, den Wickelrohrstrang um eine Außenoberfläche der Spule aufzunehmen und/oder den Wickelrohrstrang teilweise innerhalb der Spule aufzunehmen.

3. Freiwasser-Wickelrohr-Steuersystem nach Anspruch 1, wobei die Steuereinheit (40) zwischen der Spule (20) und dem Oberflächeninjektor (30) angeordnet ist.

4. Freiwasser-Wickelrohr-Steuersystem nach Anspruch 1, wobei die Steuereinheit (40) mit dem Schiff (210) verbunden oder anderweitig daran angebracht ist.

5. Freiwasser-Wickelrohr-Steuersystem nach Anspruch 1, wobei die Untersee-Hilfshebevorrichtung (50) von dem Schiff aus in das Wasser eingebracht wird.

6. Verfahren zum Bewegen eines Wickelrohrstrangs in und/oder aus Wasser, umfassend:

a. Einbringen eines Freiwasser-Wickelrohr-Steuersystems (1) auf See mit einem Schiff, wobei das Freiwasser-Wickelrohr-Steuersystem (1) Folgendes umfasst: eine Spule (20), die dazu konfiguriert ist, einen Wickelrohrstrang (100) aufzunehmen, einen von dem Schiff getragenen Oberflächeninjektor (30) in Fluidverbindung mit dem Wickelrohrstrang, eine Spulenspannvorrichtung (10), die dazu konfiguriert ist, eine von dem Wickelrohrstrang zwischen der Spule und dem Oberflächeninjektor gebildete Bogenform (110) zu steuern, eine Untersee-Hilfshebevorrichtung (50), die dazu konfiguriert ist, den Wickelrohrstrang in ein oder aus einem Unterseebohrloch zu bewegen, einen vorgegebenen Satz von Sensoren (60), umfassend einen Lastsensor, der dazu konfiguriert ist, mit

einer Last an dem Oberflächeninjektor zusammenhängende Daten zu erfassen und bereitzustellen, einen Wickelrohrstrang-Bewegungssensor, der dazu konfiguriert ist, mit Bewegung des Wickelrohrstrangs in der Spulenspannvorrichtung zusammenhängende Daten zu erfassen und bereitzustellen, wobei die Daten Bewegungsgeschwindigkeit umfassen, einen Oberflächeninjektor-Bewegungssensor, der dazu konfiguriert ist, mit Bewegung des Oberflächeninjektors zusammenhängende Daten zu erfassen und bereitzustellen, einen Schiffsbewegungssensor, der dazu konfiguriert ist, mit Bewegung des Schiffs zusammenhängende Daten zu erfassen und bereitzustellen, wobei die Daten Daten zu aktiver Tauchbewegung oder Daten zu passiver Tauchbewegung umfassen, einen Untersee-Hilfshebevorrichtungs-Lastsensor, der dazu konfiguriert ist, mit einer Last an der Untersee-Hilfshebevorrichtung zusammenhängende Daten zu erfassen und bereitzustellen, und einen Untersee-Hilfshebevorrichtungs-Bewegungssensor, der dazu konfiguriert ist, mit Bewegung der Untersee-Hilfshebevorrichtung zusammenhängende Daten zu erfassen und bereitzustellen, und eine Steuereinheit (40) in Wirkverbindung mit dem vorgegebenen Satz von Sensoren (60), wobei die Steuereinheit dazu konfiguriert ist, durch Verwenden von Informationen, die sie von dem vorgegebenen Satz von Sensoren (60) empfängt, den Wickelrohrstrang (100) auf einer vorgegebenen Spannung zu halten, um eine kontinuierliche Bewegungsrate des Oberflächeninjektors (30) gegenüber einer unterbrochenen Rate der Untersee-Hilfshebevorrichtung (50) zu bestimmen;
b. Verwenden von Bewegung des Oberflächeninjektors und der Untersee-Hilfshebevorrichtung, um einen von der Spule aufgenommenen Wickelrohrstrang durch Folgendes in ein und/oder aus einem Unterseebohrloch (200) zu bewegen:

i. Empfangen von Informationen von dem vorgegebenen Satz von Sensoren, an der Steuereinheit, die eine Last an dem Oberflächeninjektor und an der Untersee-Hilfshebevorrichtung repräsentieren;
ii. Empfangen von Informationen von dem vorgegebenen Satz von Sensoren, an der Steuereinheit zu Bewegung des Wickelrohrstrangs in der Spulenspannvorrichtung, dem Oberflächeninjektor und der Untersee-Hilfshebevorrichtung;
iii. Empfangen von Informationen von dem vorgegebenen Satz von Sensoren, an der Steuereinheit zu Bewegung des zum Tragen des Oberflächeninjektors verwendeten Schiffs;
iv. Verwenden der Steuereinheit, um die empfangenen Informationen aufzulösen, um den Wickelrohrstrang mit einer vorgegebenen Sollgeschwindigkeit in das oder aus dem Unterseebohrloch zu bewegen, um ein durch eine Einzeleingabe von einer Bedienperson befohlenes Resultat zu erreichen, wobei die Einzeleingabe von der Bedienperson einen im Wesentlichen gleichzeitig an die Spule, den Oberflächeninjektor und die Spulenspannvorrichtung gesendeten Befehl umfasst.

7. Verfahren zum Bewegen eines Wickelrohrstrangs in und/oder aus Wasser nach Anspruch 6, wobei das Halten des Wickelrohrstrangs auf einer vorgegebenen Spannung zwischen dem Oberflächeninjektor und der Untersee-Hilfshebevorrichtung ferner das Steuern der Spulenspannvorrichtung dazu umfasst, Bewegung des Wickelrohrstrangs und des Oberflächeninjektors relativ zueinander zu ermöglichen, ohne zusätzliches Aufbrauchen von Ermüdungslebensdauer infolge Tauchbewegung des Schiffs hinzuzufügen.

8. Verfahren zum Bewegen eines Wickelrohrstrangs in und/oder aus Wasser nach Anspruch 6, ferner umfassend das Verwenden der Steuereinheit, um eine kontinuierliche Bewegungsrate des Oberflächeninjektors gegenüber einer unterbrochenen Rate der Untersee-Hilfshebevorrichtung zu bestimmen.

9. Verfahren zum Bewegen eines Wickelrohrstrangs in und/oder aus Wasser nach Anspruch 6, ferner umfassend das Lösen aus der Ferne des Greifens des Wickelrohrstrangs durch die Untersee-Hilfshebevorrichtung, wenn eine von der Untersee-Hilfshebevorrichtung bereitgestellte Kraft zum Bewegen des Wickelrohrstrangs in das oder aus dem Unterseebohrloch nicht mehr benötigt wird.

Revendications

1. Un système de commande de tubulure spiralée en eau libre (1), comprenant :

a. une bobine (20) configurée pour accepter une colonne de production spiralée (100) ;
b. un injecteur de surface (30) en communication fluidique avec la colonne de production spiralée ;
c. un tendeur de bobine (10) configuré pour commander une arche (110) formée par la colonne de production spiralée entre la bobine et l'injecteur de surface ;
d. un vérin d'assistance sous-marin (50) confi-

guré pour faire entrer la colonne de production spiralée dans un puits sous-marin (200) ou en sortir ;
e. un ensemble prédéterminé de capteurs (60) comprenant :

i un capteur de charge d'injecteur de surface (61) configuré pour détecter et fournir des données relatives à une charge au niveau de l'injecteur de surface ;
ii un capteur de mouvement de colonne de production spiralée (62) configuré pour détecter et fournir des données relatives au mouvement de la colonne de production spiralée dans le tendeur de bobine, les données comprenant la vitesse du mouvement ;
iii un capteur de mouvement d'injecteur de surface (63) configuré pour détecter et fournir des données relatives au mouvement de l'injecteur de surface ;
iv un capteur de mouvement de navire (64) configuré pour détecter et fournir des données relatives au mouvement d'un navire (210), les données comprenant des données de tangage actif ou des données de tangage passif ;
v un capteur de charge de vérin d'assistance sous-marin (65) configuré pour détecter et fournir des données relatives à une charge du vérin d'assistance sous-marin ; et
vi un capteur de mouvement de vérin d'assistance sous-marin (66) configuré pour détecter et fournir des données relatives au mouvement du vérin d'assistance sous-marin ; et

f. un dispositif de commande (40) en communication fonctionnelle avec l'ensemble prédéterminé de capteurs (60), le dispositif de commande étant configuré pour utiliser les informations qu'il reçoit depuis l'ensemble prédéterminé de capteurs (60) pour maintenir la colonne de production spiralée (100) à une tension prédéterminée en déterminant une vitesse de mouvement continue de l'injecteur de surface (30) par rapport à une vitesse interrompue du vérin d'assistance sous-marin (50).

2. Le système de commande de tubulure spiralée en eau libre de la revendication 1, dans lequel la bobine est configurée pour accepter la colonne de production spiralée autour d'une surface extérieure de la bobine et/ou pour accepter la colonne de production spiralée en partie à l'intérieur de la bobine.

3. Le système de commande de tubulure spiralée en eau libre de la revendication 1, dans lequel le dispositif de commande (40) est placé en position intermédiaire entre la bobine (20) et l'injecteur de surface (30).

4. Le système de commande de tubulure spiralée en eau libre de la revendication 1, dans lequel le dispositif de commande (40) est connecté ou monté d'une autre manière sur le navire (210).

5. Le système de commande de tubulure spiralée en eau libre de la revendication 1, dans lequel le vérin d'assistance sous-marin (50) est déployé dans l'eau depuis le navire.

6. Un procédé pour faire entrer dans l'eau et/ou en sortir une colonne de production spiralée, comprenant :

a. déployer un système de commande de tubulure spiralée en eau libre (1) en mer avec un navire, le système de commande de tubulure spiralée en eau libre (1), comprenant une bobine (20) configurée pour accepter une colonne de production spiralée (100), un injecteur de surface (30) en communication fluidique avec la colonne de production spiralée et soutenue par le navire, un tendeur de bobine (10) configuré pour commander une arche (110) formée par la colonne de production spiralée entre la bobine et l'injecteur de surface, un vérin d'assistance sous-marin (50) configuré pour faire entrer la colonne de production spiralée dans un puits sous-marin ou en sortir, un ensemble prédéterminé de capteurs (60) comprenant un capteur de charge configuré pour détecter et fournir des données relatives à une charge au niveau de l'injecteur de surface, un capteur de mouvement de colonne de production spiralée configuré pour détecter et fournir des données relatives au mouvement de la colonne de production spiralée dans le tendeur de bobine, les données comprenant la vitesse du mouvement, un capteur de mouvement d'injecteur de surface configuré pour détecter et fournir des données relatives au mouvement de l'injecteur de surface, un capteur de mouvement de navire configuré pour détecter et fournir des données relatives au mouvement du navire, les données comprenant des données de tangage actif ou des données de tangage passif, un capteur de charge de vérin d'assistance sous-marin configuré pour détecter et fournir des données relatives à une charge au niveau du vérin d'assistance sous-marin et un capteur de mouvement de vérin d'assistance sous-marin configuré pour détecter et fournir des données relatives au mouvement du vérin d'assistance sous-marin, et un dispositif de commande (40) en commu-

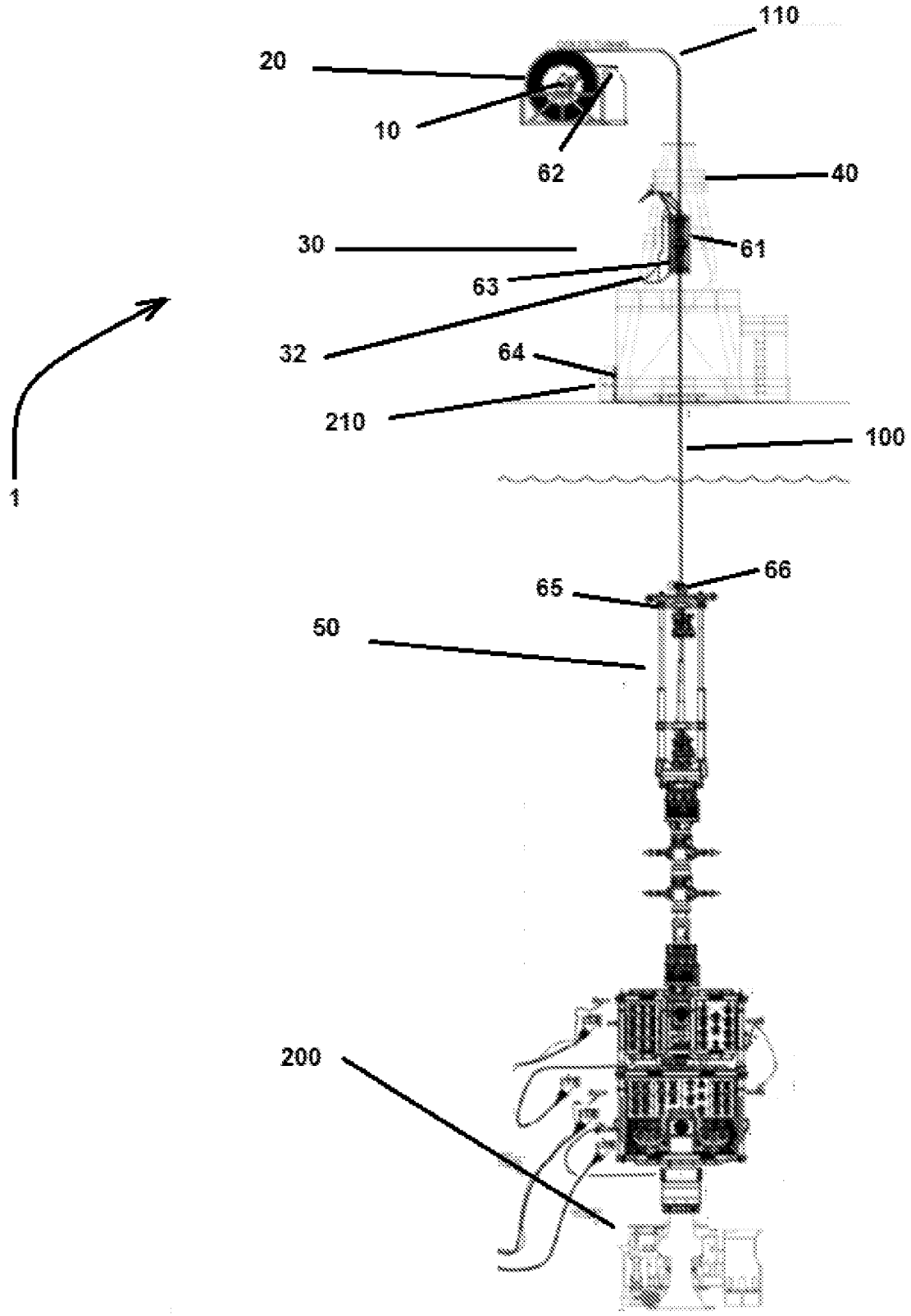
nication fonctionnelle avec l'ensemble prédéterminé de capteurs (60), le dispositif de commande étant configuré pour maintenir la colonne de production spiralée (100) à une tension prédéterminée en utilisant les informations qu'il reçoit depuis l'ensemble prédéterminé de capteurs (60) pour déterminer une vitesse de mouvement continue de l'injecteur de surface (30) par rapport à une vitesse interrompue du vérin d'assistance sous-marin (50) ;
b. utiliser le mouvement de l'injecteur de surface et du vérin d'assistance sous-marin pour faire entrer dans un puits sous-marin (200) et/ou en sortir la colonne de production spiralée acceptée par la bobine en :

i recevant des informations au niveau du dispositif de commande depuis l'ensemble prédéterminé de capteurs représentant une charge au niveau de l'injecteur de surface et au niveau du vérin d'assistance sous-marin ;
ii recevant des informations au niveau du dispositif de commande depuis l'ensemble prédéterminé de capteurs sur le mouvement de la colonne de production spiralée dans le tendeur de bobine, l'injecteur de surface et le vérin d'assistance sous-marin ;
iii recevant des informations au niveau du dispositif de commande depuis l'ensemble prédéterminé de capteurs sur le mouvement du navire servant à soutenir l'injecteur de surface ;
iv utilisant le dispositif de commande pour résoudre les informations reçues pour faire entrer dans le puits sous-marin et/ou en sortir la colonne de production spiralée à une vitesse prédéterminée souhaitée afin d'obtenir un résultat commandé par une seule entrée provenant d'un opérateur, la seule entrée de l'opérateur comprenant une commande envoyée à la bobine, l'injecteur de surface et le tendeur de bobine sensiblement simultanément.

7. Le procédé pour faire entrer dans l'eau et/ou en sortir une colonne de production spiralée de la revendication 6, dans lequel maintenir la colonne de production spiralée à une tension prédéterminée entre l'injecteur de surface et le vérin d'assistance sous-marin comprend en outre commander le tendeur de bobine pour permettre le mouvement de la colonne de production spiralée et l'injecteur de surface l'une par rapport à l'autre sans ajouter de consommation de durée de vie en fatigue supplémentaire due au tangage du navire.

8. Le procédé pour faire entrer dans l'eau et/ou en sortir une colonne de production spiralée de la revendication 6, comprenant en outre utiliser le dispositif de commande pour déterminer une vitesse de mouvement continue de l'injecteur de surface par rapport à une vitesse interrompue du vérin d'assistance sous-marin.

9. Le procédé pour faire entrer dans l'eau et/ou en sortir une colonne de production spiralée de la revendication 6, comprenant en outre le désengagement à distance du vérin d'assistance sous-marin de la prise de la colonne de production spiralée quand une force fournie par le vérin d'assistance sous-marin n'est plus requise pour faire entrer la colonne de production spiralée dans le puits sous-marin et/ou en sortir.


110
20
10
62
40
30
61
63
32
64
210
100
1
65
66
50
200

REFERENCES CITED IN THE DESCRIPTION

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