A method for controlling a subsea valve assembly includes connecting a subsea riser between a wellhead and a surface vessel. An in-riser control unit is attached to a wired pipe string and disposed within the subsea riser, resulting in the in-riser control unit being deployed in-riser. The wired pipe string is connected to a surface control unit and a communication signal is transmitted through the wired pipe string between the surface control unit and the in-riser control unit to control the subsea valve assembly.
300

Provide riser between sea floor and vessel

302

Attach in-riser control unit to a first end of a pipe string

304

Dispose in-riser control unit and pipe string into riser

306

Convey in-riser control unit to sea floor through riser

308

Attach surface control unit to a second end of the pipe string

310

Communicate between the in-riser control unit and the surface control unit through the pipe string

312

FIGURE 3
Computer System 400

414 Network

Monitor 412

404 Memory

402 Processor(s)

406 Storage Device

408 Keyboard

410 Mouse

FIGURE 4
USE OF WIRED TUBULARS FOR COMMUNICATIONS/POWER IN AN IN-RISER APPLICATION
CROSS-REFERENCE TO RELATED APPLICATIONS

This Application claims the benefit of U.S. Provisional Application 61/355,439 filed on Jun. 16, 2010.

BACKGROUND OF THE DISCLOSURE

A typical subsea well production system has a wellhead and a subsea valve assembly, such as a blow-out preventer ("BOP") or a Christmas tree, installed thereon. A riser extends upward from the Christmas tree, and together with the tree and wellhead, forms a well bore. Various well components, such as a tubing hanger, a running tool, and a test tree, are positioned in the wellbore and must be actuated to perform their respective functions. In conventional subsea well production systems, these components are hydraulically actuated through passages, which extend upward within the wellbore to the surface. The wellbore may be housed within a riser extending from a surface vessel to the sea floor. A fluid reservoir and a pump on the surface provide hydraulic pressure to the components.

Conventional systems require long hydraulic umbilical lines to span from the surface to the sea floor. The deeper the subsea well, the longer the umbilical lines must be, and the more flexure introduced into the hydraulic system, as the lines flex from the stress of the hydraulic pressure. This flexure reduces the precision to which the components can be operated. Also, there is a great distance between the controlling pump and the component being actuated which increases response times to actuate the components. In some cases, as the fluid in the long umbilical lines must traverse a large distance, such fluids are easily contaminated.

SUMMARY OF THE INVENTION

In general, in one or more embodiments, the invention relates to a method for controlling a subsea valve assembly, comprising connecting a subsea riser between a wellhead and a surface vessel, attaching an in-riser control unit to a wired pipe string, disposing the wired pipe string within the subsea riser, resulting in the in-riser control unit being deployed in-riser, connecting the wired pipe string to a surface control unit, transmitting, through the wired pipe string, a communication signal between the surface control unit and the in-riser control unit to control the subsea valve assembly.

In general, in one or more embodiments, the invention relates to a control system of a subsea valve assembly, the system comprising a subsea riser connected between a wellhead and a vessel, a controller disposed on a wired pipe string wherein the wired pipe string is disposed in the subsea riser and configured to control the subsea valve assembly, a surface control unit disposed on the vessel and configured to communicate with the controller through the wired pipe string.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is best understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

Fig. 1 shows a wired pipe in accordance with one or more embodiments of the invention.

The present disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

In general, embodiments of the invention relate to a method and system for electronic communication in production systems. Specifically, the present application describes an apparatus and method of utilizing wired pipe to transmit communication/power for production applications. More specifically, embodiments of the invention relate to an apparatus and method for wired pipe communication in an in-riser application. In one or more embodiments of the invention, a riser and/or pipe string may be wired to allow for signals and/or power to be transmitted from a rig at surface to a location proximate to the wellhead and associated well control equipment.

Now referring to Fig. 1, a wired pipe 100 (also referred to herein as wired drill pipe or wired pipe string) in accordance with one or more embodiments of the invention is shown. Wired pipe 100 may include one or more wired pipe segments 102 with each segment connected to the adjacent segments by a threaded connection. For example, Fig. 1 shows three segments (102) of the wired pipe. In one or more embodiments of the invention, the wired pipe segments 102 may include a coaxial cable 104 disposed along an interior diameter of the wired pipe segments 102. The coaxial cable 104 may extend through the length of the wired pipe 100, and may be, alternatively, any other data transfer wiring or high-speed data cable known in the art.

In accordance with one or more embodiments of the present invention, close-coupled inductive coils and magnetic field containment strategies may be used to transfer data across threaded connections. The close-coupled inductive coils and magnetic field containment strategies may be configured to prevent loss and maintain low power, high bandwidth data transfer.

Alternatively, in accordance with one or more embodiments of the present invention, to allow for data transfer between adjacent segments of wired pipe 102, the threaded connections of each segment 102 may be configured with a non-contact coupler 106. The coaxial cable 104 may be interfaced with the non-contact couplers 106 to allow for high-speed data transfer across the joints and/or threaded connection, as described herein. Data may be transferred
through the coaxial cable 104 at rates on the order of one million bits per second or more.

Alternatively still, in accordance with one or more embodiments of the present invention, the joints between adjacent segments of drill pipe may include telemetry systems. The telemetry systems at the joints may have electrical conductors inside the adjacent pipes and may be electrically coupled by high efficiency, low power transmitters that send the data across the joints.

Alternatively still, in accordance with one or more embodiments of the present invention, each of the wired pipe segments 102 may be coupled electrically via a low power, high efficiency transmitter configured to send data across each threaded pipe connection to the next segment. As such, either employing non-contact couplers 106 or transmitters, the connection of the elements of the pipe string need not be perfectly aligned to accommodate specific connectors between two segments of a pipe string.

Further, the wired pipe 100 may have various sensors, amplifiers, and/or transmitters distributed throughout the wired pipe segments along with other known electrical components known in the art. For example, as shown in FIG. 1, a transmitter 110 may be electrically configured with the coaxial cable 104 to transmit electrical signals from one section of the wired pipe 102 to another section of wired pipe 102, such as from an in-riser control unit to a surface control unit, as discussed hereinafter. An amplifier and/or repeater 108, such as a signal amplifier, may also be electrically connected to the coaxial cable 104 and may be configured to boost the signal strength of the communication signal being transferred through the wired pipe 100. Additionally, sensors 112 or other data collecting elements may be distributed throughout the length of the wired pipe 100. The sensors 112 may be electrically connected to the coaxial cable 104 and configured to send data from the sensors 112 to other elements within and/or connected to the wired pipe 100.

For example, in accordance with one or more embodiments of the present invention, amplification joints may be disposed at 1,000-foot intervals within the pipe string to boost the electrical signal. Furthermore, the amplification joints may be configured to house sensors such that measurements may be made at the amplification joints. The sensors at the amplification joints may be configured to measure temperature, pressure, seismic vibrations, and/or other attributes and/or characteristics of the wired pipe and/or riser. Alternatively, sensors may be disposed at other locations along the pipe string without departing from the scope of the present invention. Further, those skilled in the art will appreciate that any interval of amplification and/or sensor may be used without departing from the scope of the present invention. Moreover, sensors, amplifiers, and transmitters are well known in the art and will not be discussed further.

An example of a commercially available wired pipe is Intellipipe™, marketed by Grant Prideco (Houston, Tex.). Intellipipe™ uses repeater stations positioned at regular intervals in the wired pipe to boost the communication/data signal.

In view of the above, in accordance with one or more embodiments of the present invention, the data transferred via a wired pipe such as that described in FIG. 1, may be digital data and/or signals that may be transmitted at high rates with no loss or low bit error rates, providing high efficiency data transfer and/or collection. The digital data and/or signals may be used to control electrical components disposed within and/or connected to the wired pipe. Further, the digital data may include sensory data collected at various sensors and/or detectors disposed within the wired pipe and/or within and/or connected to other various components that may be configured with the wired pipe.

FIG. 2 shows a system which includes a deployed wired pipe string in accordance with one or more embodiments of the present invention is shown. More specifically, FIG. 2 shows, in one or more embodiments, an example system for employing the wired pipe 104 described above in FIG. 1. In one or more embodiments of the invention, FIG. 2 relates to a production system for executing production/well completion applications using a wired pipe such as that described above.

Referring to FIG. 2, configuration 200 includes a surface vessel 201 that may include electronic and/or hydraulic control elements 202 located on the surface vessel 201. Control elements 202 may include any known surface elements used in the production of subterranean minerals. For example, control elements 202 may include surface power distribution units, control units, chemical injection skids, and/or other hydraulic and/or electric consoles. As shown, a surface control unit 204 is installed on the surface vessel 201. Surface vessel 201 may further include a rig floor and/or other rig elements that may be used during subsea drilling and/or production operations. As such, surface vessel 201 may be ship, platform, or other surface vessel that may be used at sea for drilling and/or production of subterranean minerals, such as oil and gas.

A production string 210 may be configured to extend from the surface vessel 201 to the sea floor or mudline 205. The production string 210 may include a flowhead 212 disposed on the surface vessel 201 and may be configured for mineral extraction and production at the surface vessel 201. Control elements 202 and surface control unit 204 may be electrically connected to the production string 210.

The production string 210 may include a wired pipe string 214 which may be connected to the flowhead 212 and extend into a riser 216. The wired pipe string 214 may allow for electrical communication between the control elements 202 and surface control unit 204 and the wired pipe string and/or electrical elements connected to the wired pipe string 214. The wired pipe string as used herein may be production pipe string. As such, the pipe string may have an inner diameter greater than or equal to 5½ inches (13.0175 cm) and an outer diameter greater than or equal to 6 inches (15.975 cm). The production pipe may be used for conveying fluids, such as oil and gas, from a subterranean formation to the surface vessel for extraction and production.

Riser 216 may provide protection to wired pipe string 214 when disposed and/or deployed into water. Riser 216 may extend from the surface vessel 201 at the surface of the water down to the sea floor and/or mudline 205 and connect to subsea elements 218 such as a subsea valve assembly, blow-out preventer, subsea test tree, Christmas tree, wellhead, and/or other elements and/or units known in the art that may be installed at the sea floor for subsea mineral production.

At the sea floor end of the pipe string 214 an in-riser control unit 220 may be installed. In-riser control unit 220 may provide for control and/or monitoring of elements disposed at the sea floor. For example, in-riser control unit 220 may be used to monitor fluid flow from a subsea formation. Further, in-riser control unit 220 may monitor temperature, pressure, tension, torsion, flow rate, voltages, currents, and/or
other aspects of fluid flow and/or electrical devices disposed at the sea floor. Moreover, the in-riser control unit 220 may be configured to control and/or actuate values and/or other elements within the wired pipe string for controlling the fluid flow from the subsea formation. For example, in-riser control unit 220 may control a subsea valve assembly and/or subsea test tree.

[0028] The wired pipe string 214 may be configured to carry electrical signals from the in-riser control unit 220 at the sea floor to the surface control unit 204. The electrical signals may be control signals and/or may be measurement signals. The wired pipe string 214 allows for two-way communication between the surface control unit 204 and the in-riser control unit 220. Further, as noted above, the wired pipe string 214 may include various amplifiers, transmitters, and/or sensors distributed along the length of the wired pipe string 214 within riser 216 (not shown). In one or more embodiments of the invention, the communication signals transmitted via the wired pipe string and/or riser may be used to send control information from the surface control unit 204 to in-riser control unit 220, such as to receive feedback from in-riser control unit 220 regarding one or more of the monitored parameters.

[0029] Control at the surface, from surface control unit 204, may be through a computer interface. Alternatively, surface control unit may be a remote panel or other electrical control unit known in the art.

[0030] Now referring to FIG. 3, a flow chart for controlling a subsea valve assembly using a wired pipe string as described above in accordance with one or more embodiments of the present invention is shown. Those skilled in the art will appreciate that the process described below may be performed in a different order or may omit certain steps without deviating from the invention.

[0031] Initially, in step 302, a riser is provided between a surface vessel and production equipment on the sea floor. That is, a riser may be connected between a surface vessel and a wellhead, subsea valve assembly, BOP, and other production equipment on the sea floor. For example, in accordance with one or more embodiments of the present invention, the riser may extend from the surface vessel to a blowout preventer. The riser provides protection for pipe string that may be deployed within the riser, extending from the surface vessel to the subsea equipment. Subsea risers, as well as methods for connecting a riser as described above, are well known in the art, and thus, are not discussed in detail.

[0032] In step 304, a pipe string may be provided for deploying within the riser. In one or more embodiments of the invention, the pipe string may be a wired pipe string as described above. As such, the pipe string may be configured to have amplification joints and/or amplification elements disposed at intervals throughout the length of the pipe. At each interval, the amplifiers may be used to amplify the electrical signals that may pass through the wiring of the wired pipe.

[0033] At step 304, an in-riser control unit may be attached to the wired pipe string. The in-riser control unit may be configured to control a subsea valve assembly, a blow-out preventer, a subsea test tree, and/or other element(s) located on the sea floor, at a point where the riser connects to a sea floor unit, such as at the wellhead (i.e., at a blow-out preventer). The in-riser control unit may be installed on the wired pipe string as part of a pipe string segment or attached to a segment of pipe of the pipe string, and may be deployed into the riser at step 106. The in-riser control unit and wired pipe string may be lowered through the riser down to the unit installed on the sea floor, such as a subsea valve assembly, blow-out preventer, or other unit, at step 308.

[0034] When the in-riser control unit and wired pipe string are fully deployed into the riser, a surface control unit may be connected to the wired pipe string at the surface vessel at step 310. That is, the opposite end of the wired pipe string from the end to which the in-riser control unit is attached may connect to the surface control unit. The surface control unit may be configured to communicate with the in-riser control unit through the wiring of the wired pipe string. The surface control unit may be configured to both transmit and receive instructions and/or data/information from the in-riser control unit and/or any sensors incorporated into the wiring of the wired pipe string, as discussed above.

[0035] Finally, at step 312, the surface control unit and the in-riser control unit may communicate with each other through the wiring of the wired pipe string. The surface control unit may provide a user control over the subsea valve assembly, test tree, and/or other elements installed on the pipe string within the riser.

[0036] Those skilled in the art will appreciate that while FIG. 3 is directed toward communication using a wired pipe for in-riser applications, the process of FIG. 3 may also be performed for any production system or production application, and that embodiments of the invention are not limited to in-riser applications.

[0037] FIG. 4 shows a computing device 400 in accordance with one or more embodiments of the present invention. As shown in FIG. 4, a networked computer system 410 that may be used in accordance with one or more embodiments disclosed herein includes a processor 420, associated memory 430, a storage device 440, and numerous other elements and functionalities typical of today's computers (not shown). The networked computer system 410 may also include input means, such as a keyboard 450 and a mouse 460, and output means, such as a monitor 470. The networked computer system 410 is connected to a local area network (LAN) or a wide area network (e.g., the Internet) (not shown) via a network interface connection (not shown). Those skilled in the art will appreciate that these input and output means may include many other forms. Additionally, the computer system may not be connected to a network. Further, those skilled in the art will appreciate that one or more elements of a aforementioned computer 410 may be located at a remote location and connected to the other elements over a network. As such, a computer system, such as the networked computer system 410, and/or any other computer system known in the art may be used in accordance with embodiments disclosed herein, such as by having a computer system coupled to and/or included within a casing tool of the present disclosure.

[0038] The networked computer system 400 of FIG. 4 may be used, in one or more embodiments of the invention, as a remote workstation operatively connected to the surface control unit described in FIG. 2 above. The data collected at the surface control unit may be transmitted to such a remote workstation for further processing and analysis. Alternatively, the networked computer system 400 may represent the surface control unit on the surface vessel.

[0039] Embodiments of the invention provide for communication signals to be transmitted for in-riser applications via a wired pipe string and/or riser from a rig at the surface to a wellhead or wellhead control device. For example, signals may be transmitted in wired drill pipes (e.g., IntelliPipe™)
for use with drilling equipment. To facilitate such in-riser application communication, embodiments of the invention provide topside communications and/or a power distribution unit, production/completion tubular modified for long-hop communications/power transmission, communication and/or power repeaters, and/or wired tubular interface for an in-riser control system.

[0040] The foregoing description features several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions and alterations herein without departing from the spirit and scope of the present disclosure. Accordingly, the scope of the invention should be limited only by the attached claims.

What is claimed is:

1. A method for controlling a subsea valve assembly, comprising:
   - connecting a subsea riser between a wellhead and a surface vessel;
   - attaching an in-riser control unit to a wired pipe string;
   - disposing the wired pipe string within the subsea riser, resulting in the in-riser control unit being deployed in-riser;
   - connecting the wired pipe string to a surface control unit;
   - transmitting, through the wired pipe string, a communication signal between the surface control unit and the in-riser control unit to control the subsea valve assembly.

2. The method of claim 1, wherein a wire of the wired pipe string comprises a coaxial cable.

3. The method of claim 1, wherein the wired pipe string comprises production pipe string.

4. The method of claim 1, further comprising monitoring the subsea test tree through the wired pipe string.

5. The method of claim 4, wherein at least one of a pressure, temperature, tension, torsion, flow rate, voltage, and current are monitored.

6. The method of claim 1, wherein the method is employed for communication during in-riser well completion.

7. The method of claim 1, wherein the method is employed for communication during in-riser well production.

8. The method of claim 1, further comprising installing one or more amplifiers along the wired pipe string, resulting in a signal amplification of signals communicated along the wired pipe string.

9. The method of claim 1, further comprising installing one or more sensors along the wired pipe string, resulting in sensing along the wired pipe string.

10. The method of claim 9, wherein at least one of a pressure, temperature, tension, torsion, flow rate, voltage, and current are monitored by the one or more sensors.

11. A control system of a subsea valve assembly, the system comprising:
   - a subsea riser connected between a wellhead and a vessel;
   - a controller disposed on a wired pipe string wherein the wired pipe string is disposed in the subsea riser and configured to control the subsea valve assembly;
   - a surface control unit disposed on the vessel and configured to communicate with the controller through the wired pipe string.

12. The control system of claim 11, wherein a wire of the wired pipe string comprises a coaxial cable.

13. The control system of claim 11, wherein the wired pipe string comprises production pipe string.

14. The control system of claim 11, wherein the controller is configured to monitor at least one of a pressure, temperature, tension, torsion, flow rate, voltage, and current.

15. The control system of claim 11, further comprising one or more amplifiers disposed along the wired pipe string configured to amplify signals communicated along the wired pipe string.

16. The control system of claim 11, further comprising one or more sensors disposed along the wired pipe string.

17. The control system of claim 16, wherein at least one of a pressure, temperature, tension, torsion, flow rate, voltage, and current are monitored by the one or more sensors.

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