A technique facilitates collection of information on desired production related parameters in a subsea valve system. Collected data can be processed in a manner that enables enhanced production and/or an increased knowledge regarding operation of the entire subsea valve system. Sensors are coupled with a plurality of subsea valves, and those subsea valves are positioned at appropriate locations along a subsea hydrocarbon production system. The sensors also may be coupled with a data processing system to process the collected data for use by a well operator.
SYSTEM AND METHOD FOR MONITORING SUBSEA VALVES

BACKGROUND

[0001] In subsea well systems, hydrocarbon based fluids may be produced from multiple wells located at the seabed. The produced fluid is directed into a variety of production lines and/or other systems that ultimately direct the fluid to a collection facility located at the surface. The flow of fluid from each well and along the various subsea production lines and systems is controlled by various valves that can be located at the wellheads or at various locations along the production flow. However, the well fluid production operation can be inhibited by lack of knowledge regarding various operational parameters with respect to the valves.

SUMMARY

[0002] In general, the present application provides a system and methodology that utilize sensors in cooperation with subsea valves to provide information on desired operational parameters. The data can be processed in a manner that enables enhanced production and/or an increased knowledge regarding operation of the entire subsea valve system. Sensors are coupled with a plurality of subsea valves, and those subsea valves are positioned at appropriate locations along a subsea hydrocarbon production system. The sensors may be coupled with a data processing system to process the collected data for use by a well operator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Certain embodiments will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

[0004] FIG. 1 is a schematic illustration of a subsea well system, according to an embodiment;
[0005] FIG. 2 is a schematic illustration of a subsea valve and sensor system used in cooperation with other subsea sensor systems, according to an embodiment;
[0006] FIG. 3 is a front view of one example of a valve that can be incorporated into the subsea valve system, according to an embodiment;
[0007] FIG. 4 is a front view of another example of a valve that can be incorporated into the subsea valve system, according to an embodiment; and
[0008] FIG. 5 is a front view of another example of a valve that can be incorporated into the subsea valve system, according to an embodiment.

DETAILED DESCRIPTION

[0009] In the following description, numerous details are set forth to provide an understanding of various present embodiments. However, it will be understood by those of ordinary skill in the art that embodiments may be practiced without at least some of these details and that numerous variations or modifications from the described embodiments may be possible.

[0010] The present application relates to a system and methodology to facilitate accumulation and evaluation of data from sensors associated with subsea valves used in subsea hydrocarbon production systems. For example, a variety of sensors, such as pressure and/or temperature sensors, can be integrated into subsea remotely operated valves. The subsea valves may be actuated with control signals to control flow in the subsea production system, and the sensors can be used to monitor a variety of operational parameters related to flow through the valves, application of control signals, valve response, and other operational parameters. In one specific example, the sensors are combined with safety valves to provide, for example, temperature measurements and pressure measurements indicative of the safety valve operation. The sensors may be used to provide data in real time which enhances an operator's ability to "know-the-well" and to adjust production operations in response to the data collected from the sensors.

[0011] The sensors combined with subsea valves may be used to monitor pressure, temperature, control signals, valve actuation position, and other subsea valve related parameters. The data is provided to one or more data processing systems to facilitate monitoring and troubleshooting with respect to the overall subsea valve system. For example, data may be provided from sensors integrated into remotely operated valves on subsea pods, in subsea manifolds, and along jumper lines, flow lines, and subsea trees. The signals from the various integrated sensors may be provided to the one or more data processing systems, e.g. a central processing station, for analysis. In many applications, the sensors associated with the subsea valves can be used to monitor parameters inside and/or outside of the valves while also monitoring operating signals applied to the valves, regardless of whether the valves are hydraulically, pneumatically, electrically, or otherwise actuated.

[0012] In some applications, the sensing system may be operated in conjunction with safety systems when, for example, a hydraulic control system is the primary system for valve operation. Sensors may be integrated into the subsurface safety valve product body which enables the elimination of a separate hardware component while expanding the functionality of such subsurface safety valves with respect to monitoring flow related parameters.

[0013] The subsea sensors can be integrated into a variety of subsea valves to create instrumented valves useful in many subsea applications. For example, the instrumented valves may be used in applications where monitoring of production is important with respect to meeting efficient production targets. The instrumented valves also may be used in other tangential systems related to production of hydrocarbon fluids, such as well treatment systems, e.g. chemical injection systems. In many applications, the instrumented valves substantially expand the ability to accumulate and evaluate data that improve operation of the subsea well system. The ability to monitor desired operational parameters is useful at subsea safety valves and at many other valves positioned along the subsea flow network. Collection of this type of sensor data facilitates selection of well operations for enhanced production while also providing useful knowledge with respect to operation of the entire subsea valve system.

[0014] Referring generally to FIG. 1, one example of a subsea production system 20 is illustrated. In this example, subsea production system 20 is designed for the production of hydrocarbon fluids, e.g. oil and/or gas, and comprises a plurality of subsea wells 22 located along a seabed 24. The subsea production system 20 further comprises a surface facility 26 that may comprise a floating or anchored surface platform 28 or another type of surface facility, such as a surface vessel.

[0015] Fluids, e.g. oil and/or gas, are produced from subsea wells 22 to a surface location which may be at or proximate
The fluids are routed to the surface location via a plurality of production lines 30. As the produced fluids are routed from subsea wells 22 along production lines 30, the fluids may be directed through various other subsea structures, such as a subsea manifold 32. The flow of produced fluids (as well as the flow of injected fluids) may be controlled by valves 34 positioned along the flow path at desired locations selected according to the overall configuration of subsea production system 20.

Valves 34 may comprise a variety of valve types positioned at various locations along the production lines 30, including positions within subsea manifold 32, to control and to combine the flow of fluids from multiple subsea wells (or flow to the multiple subsea wells). Various types of valves 34 also may be positioned in wellheads 36, e.g. subsea Christmas trees, associated with the corresponding subsea wells 22. In some applications, each wellhead may comprise one or more safety valves. Additionally, valves 34 can be deployed in wellbores 38 as part of the completion equipment or other downhole equipment.

In the embodiment illustrated, subsea production system 20 further comprises a sensor system 40 associated with the subsea valves 34. The sensor system 40 may comprise a plurality of sensors 42 positioned in cooperation with corresponding valves 34 to sense desired well related parameters. For example, the sensors 42 can be used to detect fluid parameters, e.g. temperature and/or pressure, of fluid flowing internally and/or externally of specific individual valves 34. Additionally, sensors 42 can be used to monitor control signals delivered to valves 34 to control actuation of the valves. For example, the sensors 42 can be configured to detect specific control signals and/or to detect the state of actuation of specific valves.

Data collected by sensors 42 is sent to a processing system 44 to enable processing and evaluation of the data in a manner that provides knowledge related to operation of the overall subsea production system. The knowledge gained can be used to enhance production from subsea wells 22. In the embodiment illustrated, data from sensors 42 is delivered via communication lines 46 which may comprise physical communication lines, e.g. electrical lines, fiber-optic lines and/or other physical communication lines, or wireless communication lines. Processing system 44 may be located at single or plural locations depending on the type of processing system utilized. In the example illustrated, the processing system 44 is located at the surface on surface facility 26. The sensors 42 of sensor system 40 may be used to provide data in real time to enable real time analysis of the subsea operation of production system 20. The real time data also facilitates timely adjustments to the subsea production system, such as adjustments to individual valves 34 controlling the flow of fluids between the wellbores 38 and surface facility 26.

Referring generally to FIG. 2, processing system 44 is illustrated as operatively coupled with subsea valve sensor system 40 and other sensor systems that can be used in the design of production and/or well treatment applications. The processing system 44 may be dedicated to subsea valve sensor system 40 in which the various sensors 42 are associated with specific subsea valves 34. However, processing system 44 also can be designed to receive and analyze data from other sensor systems 48 having sensors 50 designed to monitor other aspects related to specific subsea well applications. For example, sensor systems 48 may be dedicated to measuring downhole parameters or parameters related to specific subsea components. Individual sensor systems 48 also may be dedicated to measuring environmental parameters and other parameters related to the subsea production operation or other subsea operation.

Depending on the number and type of sensors as well as the desired processing to be performed on the collected data, processing system 44 may have a variety of configurations. According to one embodiment, processing system 44 is designed to both process data received from the various sensors, e.g. sensors 42, and to provide control signals for controlling actuation of valves 34. Additionally, processing system 44 may be designed as an automated system that automatically provides programmed control signals to control the subsea valves 34 in response to specific data measured via sensors 42.

In the example illustrated, the processing system 44 comprises a computer-based processing system having a central processing unit (CPU) 52. CPU 52 is operatively coupled to sensor system 40 and thus to subsea sensors 42, which may comprise temperature sensors, pressure sensors, signal sensors, actuation sensors, and other sensors that detect parameters associated with valves 34. In the example illustrated, CPU 52 also is operatively coupled with a memory 54, an input device 56, and an output device 58. Input device 56 may comprise a variety of devices, such as a keyboard, mouse, voice-recognition unit, touchscreen, other input devices, or combinations of such devices. Output device 58 may comprise a visual and/or audio output device, such as a monitor having a graphical user interface. The actual processing of data may be performed on a single device or multiple devices at the surface facility location, away from the surface facility location, or with some devices located at the surface facility 26 and other devices located remotely.

The types of valves 34 employed in a given application can vary depending on the specific configuration or subsea production system 20, including the configuration of subsea wells 22 and the associated wellheads 36. Many types of valves 34 can be used in a variety of applications and at a variety of locations along the subsea production system 20. In FIG. 3, for example, a subsea gate valve 60 is illustrated and comprises an actuator portion 62 and a valve portion 64. The actuator portion 62 can be controlled via processing system 44 to selectively actuate valve portion 64 for controlling flow through subsea gate valve 60 along flowpath 66. In this example, a plurality of sensors 42 is integrated into valve portion 64 to provide an instrumented subsea gate valve. The sensors 42 may comprise temperature sensors, pressure sensors, control signal detection sensors, and other sensors for detecting a variety of operational parameters, including characteristics of the fluid flowing through subsea gate valve 60.

Valves 34 also may comprise one or more subsea ball valves 68, as illustrated in FIG. 4. In the embodiment illustrated, the subsea ball valves 68 comprise an actuator portion 70 and a valve portion 72. Actuation portion 70 may be controlled via processing system 44 to selectively rotate a ball 74 positioned to control fluid flow through the subsea ball valve 68. In this example, sensors 42 also are integrated into the valve to provide an instrumented subsea ball valve. The sensors 42 may comprise temperature sensors, pressure sensors, control signal detection sensors, and other sensors for detecting a variety of operational parameters, including characteristics of the fluid flowing through subsea ball valve 68. Both subsea gate valve 60 and subsea ball valve 68 may be
employed at a variety of locations along the subsea production lines 30 and/or in various subsea components, such as subsea manifold 32.

[0024] Referring generally to FIG. 5, valves 34 also may comprise safety valves 76 positioned, for example, in wellheads 36 and/or in wellbores 38. The one or more safety valves 76 also may be coupled with processing system 44 and comprise one or more sensors 42 to monitor various operational parameters. In some applications, real time data provided by sensor 42 to processing system 44 enables prompt monitoring and evaluation of flow through the wellhead 36 to ensure dependable, optimized production from the subsea well 22.

[0025] The valves 34 and sensors 42 can be combined in a variety of configurations to provide data to processing system 44. Additionally, processing system 44 can be programmed to respond in various ways to data obtained at the plurality of valves 34 via sensors 42. For example, processing system 44 may be programmed to output information to an operator and/or to automatically output control signals to the various valves 34. The control signals sent to valves 34 are used to adjust, for example, fluid flow through various regions of the subsea production system. The number and type of wells may vary from one subsea application to another. Additionally, the various subsea components and equipment also may be different from one application to another depending on environmental, operational, and other factors. The valve type and the sensor type also may vary depending on the configuration of the overall subsea production system, the environment, and the optimization goals for a given application. Additionally, the valves may be instrumented by multiple types of sensors to detect and monitor a plurality of operational parameters.

[0026] Accordingly, although only a few embodiments have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings envisioned in this application. Such modifications are intended to be included within the scope of this application as defined in the claims herein or subsequent related claims.

What is claimed is:

1. A system for use in a subsea well environment, comprising:
   a plurality of subsea wells linked by production lines that direct flow of produced hydrocarbon fluids;
   a plurality of subsea valves positioned to control flow of the hydrocarbon fluids along the production lines; and
   a plurality of sensors with at least one sensor associated with each subsea valve of the plurality of subsea valves to provide real time data on an operational parameter related to the plurality of subsea valves.

2. The system as recited in claim 1, wherein the plurality of sensors comprises a plurality of temperature sensors.

3. The system as recited in claim 1, wherein the plurality of sensors comprises a plurality of pressure sensors.

4. The system as recited in claim 1, wherein the plurality of valves comprises a subsea gate valve.

5. The system as recited in claim 1, wherein the plurality of valves comprises a subsea ball valve.

6. The system as recited in claim 1, wherein the plurality of valves comprises a subsea safety valve positioned at each subsea well.

7. The system as recited in claim 1, further comprising a processing system positioned at a surface location and coupled to the plurality of sensors to process real time data provided by the plurality of sensors.

8. The system as recited in claim 7, wherein the processing system receives data from additional production related sensor systems.

9. The system as recited in claim 8, wherein the processing system is located on a production platform.

10. A method, comprising:
    producing a hydrocarbon fluid from a plurality of subsea wells;
    controlling flow of the hydrocarbon fluid with a plurality of valves; and
    obtaining data from sensors located at the plurality of valves to enable an evaluation of production.

11. The method as recited in claim 10, wherein obtaining data comprises obtaining data in real time.

12. The method as recited in claim 10, wherein controlling comprises adjusting the plurality of valves based on the data obtained from sensors.

13. The method as recited in claim 10, wherein producing comprises producing oil.

14. The method as recited in claim 10, wherein obtaining comprises monitoring valve control signals.

15. The method as recited in claim 10, wherein obtaining comprises obtaining data via a plurality of temperature sensors mounted in the plurality of valves.

16. The method as recited in claim 10, wherein obtaining comprises obtaining data via a plurality of pressure sensors mounted in the plurality of valves.

17. A system, comprising:
   a computer based data processing system; and
   a plurality of sensors to provide data to the computer based data processing system, the plurality of sensors being coupled with a plurality of subsea valves operated to control flow of hydrocarbon-based fluid.

18. The system as recited in claim 17, wherein the plurality of sensors is coupled with subsea valves located in subsea wellbores.

19. The system as recited in claim 17, wherein the plurality of sensors is coupled with subsea valves located along subsea production lines.

20. The system as recited in claim 17, wherein the plurality of sensors comprises temperature sensors.

21. The system as recited in claim 20, wherein the plurality of sensors comprises pressure sensors.

22. A method for use in a subsea well environment, comprising:
   placing sensors in a plurality of subsea valves;
   locating the plurality of subsea valves in a subsea hydrocarbon production system; and
   coupling the sensors with a data processing system.

23. The method as recited in claim 22, further comprising monitoring a desired parameter at each subsea valve of the plurality of subsea valves; and adjusting selected subsea valves of the plurality of subsea valves based on sensor data processed on the data processing system.

24. The method as recited in claim 22, further comprising using the sensors to provide real time data to the data processing system.

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