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Simplified High Pressure and High Volume Fluid Delivery

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BACKGROUND

[0001] Several applications including drilling rigs involve handling multiple fluids that are to be delivered to various portions of the rig under varied conditions such as high pressure (e.g., >15K) and/or involving high fluid volume transfer rates (e.g., 4000 gallons per minute (gpm)). In some implementations, the fluids can include mud, pressure pumping, cement, and/or other completion fluids. Typically, such applications can use delivery systems implemented for each type of fluid. However, set up and maintenance of delivery systems targeted for each type of fluid in drilling rigs (e.g., offshore drilling rigs) can lead to extensive costs. Thus, there exists a need for a multi-fluid delivery system that is configured to handle delivery of a variety of fluids.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 is an example schematic illustration of a multi-fluid delivery system, according to some embodiments.

[0003] FIG. 2 is an example schematic illustration of a multi-fluid delivery system, according to some embodiments.

DETAILED DESCRIPTION

[0004] Fluid delivery systems are for a variety of operations including drilling wellbores, i.e., holes that are dug in the Earth's sub-surface to facilitate the extraction of natural resources, such as oil, gas, minerals, water, etc., and/or retrieving extracted natural resources, etc. In some implementations, such operations involve transfer of a variety of fluids under a variety of conditions. For example, multiple fluids may be transferred against natural gradients (e.g., fluids pumped against a pressure or density gradient) in large volumes. Several such operations can be rate limited by the speed and/or efficiency of delivery of multiple fluids. Furthermore, the handling of one fluid in the fluid delivery system can affect the efficiency of use of the system for another fluid (e.g., return systems or processing systems incorporated to flush the fluid delivery systems after each use, etc.,)

[0005] Systems and methods described herein facilitate handling of multiple fluids using multi-fluid delivery systems that can be used in combination with the fluid delivery systems mentioned above to efficiently transfer and obtain the extracted natural resources while safely disposing the by products from operations. In some embodiments, pumping system and methods are described to handle cement, mud, and pressure pumping material.

[0006] In some instances, offshore drilling operations can use specialized support vessels configured to handle the transfer of fluids, which are used to increase a cost efficiency associated with extraction of resources. Typically, these support vessels are configured to utilize conventional reciprocating positive displacement pump technology, bulk storage and transport, fluid mixing and transfer systems, and large power plants to provide services to a variety of customers. Combining multi-fluid delivery systems, as described herein, can aid in accomplishing multi-fluid handling functions, that conventionally require a separate vessel, in an efficient manner by designing a system on an existing rig vessel to perform that same function, thereby reducing costs associated with an operation and increasing the utility of support vessels several fold.

[0007] The high pressure, high volume (HPHV) multi-fluid delivery system described herein can increase the marketability of existing vessels equipped for offshore drilling operations. The use of the described multi-fluid delivery system can also reduce the cost associated with transport and use of a vessel purposed with offshore drilling operations, by using the same fluid delivery system for multiple fluids, while maintaining and/or adding functionality to the vessel. In some embodiments, MODUs (drillships and semi-submersibles), and jackups can be equipped with bulk transport, fluid mixing and delivery, and power plant systems commonly included on support vessels. Incorporating new hydraulic pumping technology can create a synergy between the vessels' existing infrastructure and the systems described herein. The pumping systems and/or methods described can be used to replace cement, mud, and high-pressure high-volume pumps used in conventional systems, in turn reducing a spread rate and increasing the efficiency of a rig.

[0008] In some embodiments, the systems and methods described here include a multi-fluid delivery system (also referred to herein as "the system") that includes combining conventionally available fluid handling technology implemented in a unique way. In some embodiments, a multi-fluid delivery system can include the use of one or more hydraulic positive displacement pumps arranged on a rig built in a vessel to provide high pressure, high flow rate fluid. The system can also include bulk, mixing, and transfer systems, among other components, to prepare mud, cement, or pressure pumping fluid for delivery to the pump.

[0009] In some embodiments, the multi-fluid delivery system can be a high pressure high volume (HPHV) fluid delivery system, (also referred to as "as the HPHV system" or the “HPHV multi-fluid system") that mixes and delivers mud, cement, pressure pumping, and completions fluids to a well of a drilling operation. In some embodiments, the system can be used in a Mobile Offshore Drilling Unit (MODU) wherein the system combines multiple services (e.g., drilling, pressurized fractioning, extraction, etc.). In some instances, the multi-fluid delivery system described herein can be configured as a package arranged in a MODU, the package configured to perform, in a unified manner, services and/or operations that were previously provided by several third parties.

[0010] FIG. 1 illustrates a schematic representation of an example HPHV multi-fluid delivery system 100, arranged on a MODU, according to an embodiment. In some implementations, as an example configuration, the system 100 can utilize existing bulk storage and transfer systems, mud mixing and transfer systems, and/or power plants to store, prepare and deliver mud, cement, pressure pumping fluid, or completions fluid to a set of novel positive displacement pumps powered and controlled by an electrohydraulic system. In other implementations, different numbers of pumps, cylinders, etc. may be used to suit a particular application.

[0011] As an example, the HPHV multi-fluid delivery system 100 (or the system 100) includes, among other components, HPHV pumps 110, bulk storage 120, a mixing unit 130, and mixed fluid storage unit 140. The system 100 includes fluid transfer systems and/or fluid transfer lines indicated by arrows configured to transfer fluids from one unit to another. As illustrated in FIG. 1 the system 100 includes bulk transfer system or the bulk transfer line 185 configured to transfer fluid from the bulk storage 120 to the mixing unit 130. The system 100 includes mixed fluid transfer system / transfer line 125 configured to transfer fluid from the mixing unit 130 to the mixed fluid storage 140. The system 100 includes fluid or liquid supply header lines 115 configured to supply fluids (e.g., mud, completion fluid, cement, liquid, or any other suitable fluid), and discharge headers 135 fluidically coupling the HPHV pumps 110 for delivery to the well at 145 (e.g., borewell drilled to extract natural resources).

[0012] The system 100 includes one or more supply lines (e.g., supply lines 165, 175) that can be configured to receive from and/or send discharge to another vessel (e.g., an offshore supply vessel or OSV). The supply lines can be configured to handle a variety of fluids. For example, as illustrated, the system 100 includes the mixed fluid supply / discharge line 165 via a loading station (not shown in FIG. 1). The system 100 also includes a bulk supply / discharge line 175 used to send and/or receive one or more fluids via a loading station (not shown in FIG. 1). 175

[0013] The HPHV pumps 110 can be configured to discharge through a pipe network to the well via a dedicated high-pressure, high-volume connection via the delivery to the well 145. In some implementations, the bulk stores 120 can store and deliver components required for the operation. The mixing system 130 can be configured to receive bulk from the bulk store 120 via the bulk transfer system 185 through any suitable means. For example, the mix system 130 can prepare mud, brine, cement, and pressure pumping fluid according to a predetermined specification (e.g., predetermined ingredients, constituency, consistency, etc.). In some instances, specialized mixing equipment may be used for each fluid type. The mixed fluid transfer system 125 can move the fluid from one or more shared or dedicated storage pits to the high-pressure, high-volume pumps 110.

[0014] The high-pressure, high-volume pumps 110 can be configured to use a hydraulic cylinder and hydraulic control package to convert electrical energy into fluid pumping power. In some implementations, the HPHV pumps can include installation of six pumps configured with 6x 6000 hP (36,000 hP) or about 26,845 kW equivalent fluid power. Existing power plants on rigs have capacity to deliver the high power requirement. The HPHV pumps can be configured such that the fluid moves from the HPHV pumps to a dedicated manifold mounted on the drill floor. The pumps can be fluidically connected to the well through a dedicated injection head and frac iron or co-flexip hose.

[0015] FIG. 2 illustrates a schematic representation of a HPHV multi-fluid delivery system 200, according to another embodiment. The HPHV multi fluid system 200 (also referred to as the system 200) can be similar to, in form and/or in function, the system 100 described above with reference to the FIG. 1. For example the system 200 includes six HPHV pumps 210, each pump receiving charge from one or more of the bulk storage units 220A-220F with each dedicated storage unit housing a dedicated fluid. The units 220A and 220B are shown to be including mud, the unit 220C dedicated for cement, unit 220D for brine, unit 220E for pressure pumping, and unit 220F is shown for cleaning fluid. As an example, the Mud 1 system including the unit 220A can be used to supply mud to the well and the Mud 2 system including the unit 220B can be used to supply seawater to the well. In some embodiments, the system 200 can include a mixing unit, and mixed fluid storage unit (not shown).

[0016] The system 200 includes fluid transfer systems and/or fluid transfer lines (e.g., 215, 235 etc.,) indicated by the connecting lines in the schematic indicated by the reference numeral, for example 215 and 235, and the associated arrows. The fluid transfer lines can be configured to transfer fluids from one unit to another. For example, as indicated in FIG. 2, the system 200 includes bulk transfer systems or the bulk transfer lines 215 that can be configured to transfer fluid from the dedicated bulk storage units 220A-220F to the pumps 210. In some implementations, the bulk transfer lines 215 can also serve as supply header lines similar to the supply header lines 115 described with reference to the system 100 above. The system 200 includes fluid transfer systems / transfer lines serving as discharge headers 235 to fluidically couple the HPHV pumps 210 for delivery to the well at 245 (e.g., bore well drilled to extract natural resources).

[0017] In some implementations, the system 200 can include one or more additional systems included to aid with the handling and/or processing of the variety of fluids delivered by the system 200. As shown in FIG. 2, the system 200 includes a brine return system 222 configured to work with the brine delivery portion of the system 200 (e.g., the bulk storage unit for brine at 220D). In some instances, the HPHV multi-fluid system 200 can used with brine based drilling fluids that have become widely utilized systems for drilling during an entire productive interval of a drilling set up due to their ability to protect the formation while drilling. Brine fluids can be formulated with brine as the liquid phase. The brine return system 222 can be configured to cycle the brine based fluids through the system 200 for drilling and any other suitable operations. While the system 200 is shown to include a brine return/processing system 222, in some alternative embodiments the brine return system may not be included / necessary.

[0018] As shown in FIG. 2, the system 200 can include a mud return/processing system 242 configured to work with the mud delivery portion of the system 200 (e.g., the bulk storage units for mud at 220A and 220B). The drill bit can be configured such that the drilled mud sprays out of nozzles on the drill bit, cleaning and cooling the drill bit in the process. The mud can be made to carry the crushed or cut rock ("cuttings") up the annular space ("annulus") between the drill string and the sides of the hole being drilled, up through the surface casing, where it emerges back at the surface. Cuttings can then be filtered out and the mud returns to the mud pits. The mud pits let the drilled "fines" settle. Thus, mud can be cycled through the system 200 in various states of use. The mud return/processing systems 242 can be configured to handle the various stages of using the mud supply for the above mentioned various uses. While the system 200 is shown to include a mud return/processing system 242, in some alternative embodiments the mud return/processing system may not be included / necessary.

[0019] In some implementations, the system 200 includes a managed pressure drilling (MPD) system 242 configured to implement an adaptive process to precisely control a drilling operation (e.g., more precisely control an annular pressure profile throughout the wellbore while drilling. As shown in FIG. 2, the MPD system 232 can be coupled to and between the RCD / Flow Spool 253 and the mud processing system 242). While the system 200 is shown to include a MPD system 232, in some alternative embodiments the MPD system may not be included / necessary.

[0020] As shown in FIG. 2, in some embodiments, the system 200 also includes a diverter 252 to channel fluid flow and a rotating control device (RCD) 253 in addition to a MPD system that involves annular flow of fluid. The RCD 253 can be configured to redirect the flow of fluid and help form a closed-loop circulating system through the system 200. In some embodiments, the system 200 includes a blowout preventer (BOP) 256 that includes one or more large, specialized valves or similar mechanical devices, used to seal, control and/or monitor fluids to prevent blowouts or uncontrolled release of the fluids. The system 200 includes a lower marine riser package (LMRP) 254 which can be a mechanical device configured to protect the well (e.g., oil well) located underwater (subsea). While the system 200 is shown to include the diverter 252, the RCD 253, the BOP 256, and the LMRP 254, in some alternative embodiments each one of the above mentioned systems (e.g., diverter 252) or all of these systems may not be included / necessary. For example, in some embodiments, the diverter 252 may be omitted, in some embodiments, the RCD 253 may be omitted, in some embodiments, the BOP 256 may be excluded and in some embodiments, the LMRP 254 may be excluded.

[0021] In use, the system 200 can be substantially similar in structure and/or in function, to the system 100 described above. The system 200 (and/or the system 100) can be used to deliver multiple fluids (e.g., mud1, mud2, seawater, cement, brine, and/or frac) to the well. The arrangement of the system 200 provides avenues for offline cleaning of the pipe network using the cleaning line associated with 220F. The arrangement of the system 200 also provides for line-up of the next fluid to be delivered, while cleaning the pipe work or while delivering a first fluid in a sequence of fluids. As described above, the system 200 is configured to integrate with an infrastructure designed and/or built for a MPD system (e.g., an existing infrastructure built for a MPD system 232). In some embodiments, each HPHV pump of the pumps 210 of the system 200 can include multiple fluid delivery components providing redundancy and high reliability within each HPHV pump. Each HPHV pump can be configured to reduce flow output to one cylinder under slow speed, which can provide flow control at low flow rates. In some embodiments, the system 200 can be configured to support a maximum flow rate of higher than 100 bbl/min at 15000-PSI pressure. In some embodiments, the system 200 can be configured such that fluids can be reversed out via connections provided using one or more switches (not shown in FIG. 2) between the mud and brine systems.