(54) Title: SYSTEM AND METHOD FOR CONTROLLING WELLBORE PRESSURE

(57) Abstract: A wellbore pressure control system includes a substantially constant head or lift pump coupled at an inlet thereof to a discharge port of a wellbore. The pump provides a substantially constant head or lift when operated at a constant speed. A fluid return line is coupled to an outlet of the pump and extending to the surface of the body of water. A flow control is disposed in the fluid return line, the flow control operable to controllably restrict a rate of discharge through the return line so that a selected pressure is maintained in the wellbore. A method for controlling fluid pressure in a wellbore includes pumping fluid through a pipe string extended into the wellbore from a device disposed at the surface of a body of water. The fluid is discharged through the end of the pipe string into an annular space between the pipe string and the wellbore. The fluid is pumped at substantially constant head or lift from above a top of the annular space through a return line to the surface of the water. A pressure in the wellbore is controlled by varying a restriction in the return line.
as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(Hi)) — without international search report and to be republished upon receipt of that report (Rule 48.2(g))
SYSTEM AND METHOD FOR CONTROLLING WELLBORE PRESSURE

Background of the Invention

Field of the Invention

[0001] The invention relates generally to the field of managed pressure drilling. More particularly, the invention relates to systems for maintaining a selected pressure at the bottom of a wellbore.

Background Art

[0002] U.S. Patent No. 6,415,877 issued to Fincher et al. relates to drilling systems for drilling subsea wellbores. The drilling system includes a tubing (or "drill string") that passes through a water bottom wellhead, and has a drill bit at the bottom end of the tubing or drill string. A drilling fluid system continuously supplies drilling fluid ("mud") from the surface, into the tubing, whereupon it discharges at the drill bit bottom and returns to the wellhead through an annulus between the tubing and the wellbore wall, carrying the drill cuttings. A fluid return line extending from the wellhead equipment to the drilling vessel transports the returning mud to the surface. In a "riserless" drilling arrangement, the return fluid line is separate and spaced apart from the tubing. In a system using a riser (a conduit which connects the top of the wellhead to the surface vessel), the return fluid line may be the riser itself or may be a separate line carried by the riser. The tubing may be coiled tubing with a drilling motor in the bottom hole assembly driving the drill bit. A pump coupled to the annulus is used to control the bottom hole pressure during drilling operations, making it possible to use heavier (more dense) drilling muds and drill to greater depths than would be possible without the pump. An optional delivery system continuously injects a flowable material, whose fluid density is less than the density of the drilling fluid, into the returning fluid at one or more suitable locations, wherein the rate delivery of such lighter material can be controlled to provide supplementary regulation of the pressure. Various pressure, temperature, flow rate and kick sensors included in the drilling system provide signals to a controller that controls the pump, the surface mud pump, a number of flow control devices, and the optional
lighter material delivery system. One purpose of using the system described in the Fincher et al. patent is to enable the use of higher density drilling fluid than would otherwise be possible for a wellbore drilled beneath a deep body of water. Such capability is provided by using the pump to reduce the hydrostatic pressure of the drilling fluid in the wellbore. By controlling the pump and/or rate of entry of the lighter material, it is possible to maintain a selected pressure in the wellbore.

U.S. Patent No. 7,185,719 issued to van Riet describes a drilling system that includes a pump to move drilling fluid through a drill string or tubing in a wellbore. The system includes rotating control head or similar device to seal the wellbore annulus against the drill string. A backpressure control device is coupled to an outlet of the wellbore annulus. Backpressure may be provided to the annulus by diverting some of the flow from the pump that discharges mud into the drill string (or by providing a backpressure pump) and by controlling the orifice size of a choke. The purpose for using the controllable choke and backpressure system is to enable using lower density drilling fluid than would otherwise be required to drill a particular wellbore. Using lower density drilling fluid may reduce the possibility of exceeding formation fracture pressures in certain parts of the wellbore during drilling.

It is desirable to be able to control wellbore fluid pressure using a system such as the one described in the Fincher et al. patent without the need for expensive, difficult to operate pump speed control devices for a pump disposed at great water depth.

**Summary of the Invention**

A wellbore pressure control system includes a substantially constant head or lift pump coupled at an inlet thereof to a discharge port of a wellbore. The pump provides substantially constant head or lift when operated at a constant speed. A fluid return line is coupled to an outlet of the constant head or lift pump and extends to the surface of the body of water. A flow control is disposed in the fluid return line. The flow control is operable to selectively restrict a rate of fluid discharge through the return line so that a selected pressure is maintained in the wellbore. A method for controlling fluid pressure in a wellbore includes pumping fluid through a pipe string extended into the wellbore from
a device disposed at the surface of a body of water at a selected pressure. The fluid is
discharged through the end of the pipe string into an annular space between the pipe
string and the wellbore. The fluid is pumped at substantially constant head or lift from
above a top of the annular space through a return line to the surface of the water. A
pressure in the wellbore is controlled by operating a variable restriction in the return line.

[0006] Other aspects and advantages of the invention will be apparent from the following
description and the appended claims.

Brief Description of the Drawings

[0007] FIG. 1 is a schematic diagram of an example wellbore drilling and pressure
control system according to the invention.

[0008] FIG. 2 shows a system similar to that in FIG. 1 with the inclusion of a drilling
riser.

Detailed Description

[0009] An example drilling system with a wellbore pressure control device is shown
schematically in FIG. 1. A drilling unit 10, which may be a floating drilling unit or a
bottom supported drilling platform operates on the surface of a body of water 11 such as
a lake or the ocean to support a drill string 12, which drills a wellbore 14 through rock
formations 17 below the water bottom 19. The drill string 12 includes a drill bit 26 at the
bottom end, wherein rotation of the bit by the drill string and/or a drill motor (not shown)
in the drill string 12, plus axial force exerted by part of the weight of the drill string 12
causes the bit 26 to drill the formations 17, this lengthening the wellbore 14.

[0010] A drilling fluid or "mud" pump 32 on the drilling unit 10 lifts drilling fluid
("mud") 31 from a tank 30 or pit and moves the mud 31 under pressure through an
interior passage in the drill string 12. The mud 31 leaves the drill string through courses
or jets in the bit 12 and returns toward the surface in an annular space 15 between the
wellbore 14 and the drill string 12. The mud 31 has a density or specific gravity selected
to exert a particular hydrostatic pressure in the wellbore 14. The mud pump 32 generally
operates at a constant flow rate during drilling operations. Pressure of the mud 31 as it leaves the pump 32 and enters the drill string 12 may be measured by a pressure sensor 32A in signal communication with a controller 26 (explained further below).

A subsurface wellhead 16 may be coupled to the top of the wellbore 14 (typically through a surface casing, not shown separately) to control movement of fluid into and out of the wellbore 14. The wellhead 16 typically will include one or more devices such as blowout preventers 16B (BOPs) to shut in the well in certain circumstances. The drill string 12 may enter the wellhead 16 through a rotating control head, rotating blowout preventer, rotating diverter or similar device shown at 16A in the example embodiment shown in FIG. 1. The mud 31 returning up the annular space 15 leaves the wellhead 16 through a discharge port 18 disposed in a selected part of the wellhead 14 or the diverter 16A. The discharge port 18 is connected to the inlet of a subsea mudlift pump 22, which may be a kinetic energy / centrifugal / disc type of pump suitable for moving drilling mud from the wellhead 16 to the surface. In the present invention, the subsea mudlift pump 22 may have a constant speed drive (CSD) or a variable speed drive (VSD). The subsea mudlift pump 22 will provide substantially constant head or lift when operate at a constant rotational speed (RPM). The effect of operating the subsea mudlift pump 22 at constant RPM is to provide a relatively constant head or lift to mud 31 exiting the wellbore annulus 15 and moved to the surface, assisted by the subsea mudlift pump 22. If a VSD is used, the subsea mudlift pump 22 may be operated at variable speeds to maintain a selected pressure in the discharge line 18, e.g., as measured by the pressure sensor 20.

The discharge side of the subsea mudlift pump 22 is coupled to a mud return line 24, which extends to the drilling unit 10. The mud return line 24 includes a controllable orifice choke 28 or other type of variable flow control device therein. The choke 28 may be disposed on the drilling unit 10 or other convenient location. The choke 28 outlet extends by a line (not shown) to the tank 30 (generally after passing through mud cleaning and degassing devices not shown in FIG. 1 for clarity).
In the example shown in FIG. 1, a pressure sensor 20 may be in hydraulic communication with the discharge port 18. The pressure sensor 20 may be any type of transducer that generates a signal corresponding to the pressure in the discharge port 18. The signal from the pressure transducer 20 may be coupled to the controller 26, which may be part of a general purpose computer, a programmable logic controller or any similar device that can generate control signals in response to input signals and programmed instructions. In the present example, the connection between the pressure transducer 20 may be, for example, an electrical or optical cable, or may be acoustic telemetry; none of foregoing is intended to limit the scope of the invention. In the present example, the controller 26 may include an operator input device (not shown separately) for selecting a pressure to be maintained at the discharge port 18, or the pressure may be pre-programmed into the controller 26. By maintaining such pressure, a selected pressure at the bottom of the wellbore 14 or at any other selected point along the wellbore 14 may be maintained (referred to for convenience as "wellbore pressure"). In the present example, changes in pressure at the discharge port 18 from the preselected value may be adjusted or compensated by changing the flow control 28. Such operation of the flow control (choke 28) may be performed automatically by the controller 26 or may be performed manually by a system operator. Alternatively, if the subsea mudlift pump 22 includes a VSD, the pump speed may be changed by the controller 26 to maintain a selected pressure at the discharge port 18. In still another example, both the subsea mudlift pump 22 RPM and the flow control 28 may be operated by the controller to maintain a selected pressure at the discharge port 18.

While the present example shows the subsea mudlift pump 22 in the return line proximate the wellhead 14, it should be clearly understood that the subsea mudlift pump 22 can be located at any position along the mud return line 24 between the discharge port 18 and the surface. The position of the subsea mudlift pump 22 with reference to the wellhead 14 is therefore not a limitation on the scope of the invention

In the present example, if a gas kick (gas entry into the wellbore from a formation) passes through the system (e.g., enters the wellbore and discharges through the discharge port 18), the subsea mudlift pump 22 may be operated at a substantially
constant speed by the controller 26, and the flow control (choke) 28 can be operated to control the flow rate out of the wellbore 14 to maintain a substantially constant standpipe (mud pump) pressure (measured at sensor 32A) just as with well known wellbore fluid entry (kick) kill methods, e.g., the Driller's Method.

[0016] The system shown in FIG. 1 is a so-called "riserless" system, because the drill string 12 extends through the wellhead 16 into the wellbore 14 (through the rotating diverter 16A) without being enclosed by an external conduit or "drilling riser." The system shown in FIG. 1 may also be used with systems including a drilling riser (a conduit that extends from the wellhead 16 to the drilling unit 10). In this embodiment the discharge port 18 may be located on the drilling riser at any elevation.

[0017] FIG. 2 shows such a system including a drilling riser 40 that extends from the wellhead 16 to the surface (to the drilling unit 10). The drilling riser 40 usable in accordance with the invention may be closed at the bottom end thereof, wherein a device such as the rotating control head 16A is used, or the riser 40 may be open to the wellbore annulus 15 below the wellhead 16. In the latter case, drilling fluid, water, gas (air) or combinations thereof may fill the riser to a selected level 42 above the wellhead 16 to provide some of the fluid pressure exerted in the wellbore 14. In the example shown in FIG. 2, the controller 26 may operate the choke 28 to maintain a selected fluid level 42 in the riser 40. This may be performed either in addition to maintaining a constant pressure measurement made by the transducer 20 or in substitution thereof. In the event of a fluid entry into the wellbore 14, the controller may operate the subsea mudlift pump 22 and the flow control 28 in a manner similar to that explained with reference to FIG. 1.

[0018] Wellbore drilling and pressure control systems according to the invention may enable the use of constant head or lift subsea mudlift pumps while enabling maintenance of any selected wellbore annulus and/or bottom hole pressure.

[0019] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the
invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.
Claims

What is claimed is:

1. A wellbore pressure control system, comprising:
   a substantially constant head or lift fluid pump when operate at constant speed coupled at
   an inlet thereof to a discharge port of a wellbore;
   a fluid return line coupled to an outlet of the pump and extending to the surface of the
   body of water; and
   a flow control disposed in the fluid return line, the flow control operable to control a
   pressure in the wellbore to a selected value.

2. The system of claim 1 wherein the flow control is operated by a controller in signal
   communication with a pressure transducer disposed proximate the flow outlet of the
   wellbore.

3. The system of claim 1 wherein the flow control comprises a variable orifice choke.

4. The system of claim 1 further comprising a riser extending from a wellhead at the fluid
   outlet to the wellbore to the surface, the riser at least partially filled with fluid to provide
   hydrostatic pressure in the wellbore.

5. The system of claim 1 wherein the substantially constant head or lift pump comprises a
   constant speed drive.

6. The system of claim 1 wherein the substantially constant head or lift pump comprises a
   variable speed drive.

7. The system of claim 6 wherein the controller is configured to operate the substantially
   constant head or lift pump at a substantially constant speed and to operate the flow
   control to maintain a selected wellbore pressure in the event of a fluid entry into the
   wellbore from a formation adjacent thereto.
8. The system of claim 1 wherein the substantially constant head or lift pump is located proximate the top of the wellbore.

9. The system of claim 1 wherein the substantially constant head or lift pump is located at a selected position along the fluid return line between the top of the wellbore and the water surface.

10. A method for controlling fluid pressure in a wellbore, comprising:
    pumping fluid through a pipe string extended into the wellbore from a device disposed at the surface of a body of water;
    discharging the fluid through the end of the pipe string into an annular space between the pipe string and the wellbore;
    pumping the fluid from above a top of the annular space through a return line to the surface of the water using a substantially constant head or lift subsea mud lift pump disposed in the return line, wherein the substantially constant head or lift pump provides substantially constant head or lift when operated at a constant speed; and
    controlling a variable restriction in the return line to maintain a selected pressure in the wellbore annular space.

11. The method of claim 10 wherein the controlling the restriction comprises operating a variable orifice choke.

12. The method of claim 10 wherein the controlling pressure comprises controlling a flow restriction in the return line in response to pressure measured proximate a top of the annular space.

13. The method of claim 10 further comprising exerting at least part of the pressure in the wellbore by extending a riser from a wellhead disposed at a top of the wellbore to the surface and at least partially filling the riser with fluid to exert part of the selected pressure in the wellbore.
14. The method of claim 13 further comprising operating the flow restriction to maintain a selected fluid level in the riser.

15. The method of claim 10 further comprising operating the flow restriction to maintain a substantially constant pressure in the wellbore while the pumping the fluid from above the top of the annular space is performed at a substantially constant head or lift.

16. The method of claim 15 wherein the maintaining substantially constant pressure of fluid in the wellbore is performed in response to fluid entering the wellbore from a formation adjacent thereto.
FIG. 1