

PUMPS**Field of the Invention**

The present invention relates to pumps, in particular to pumps for pumping hydraulic well control fluid into a production flowline of a well.

Background of the Invention

During the operation of a subsea well, hydraulic fluid is expelled from hydraulic control actuating devices, such as valve and choke actuators. Typically, in the past, this fluid has been exhausted to the sea. The fluid is, typically, ethylene glycol based and is now considered to be a pollutant. Environmental legislation now prompts well operators to stop exhausting such fluids into the sea, particularly on new installations, which presents well equipment suppliers with the problem of finding a solution to the new requirements. GB Patent Application No. 0820326.7 discloses a method of disposing of hydraulic well control fluid, comprising pumping the fluid into a production flowline of the well. Although it is possible to effect such a method with an electrically powered pump, a failure of electric power would not allow hydraulic fluid to continue to be exhausted from actuators during the well shut down. The present invention enables a pump that provides the necessary pressure to inject exhausted hydraulic fluid into the production flowline, handles the fluid exhausted during a well shut down and does not need electric power.

Summary of the Invention

According to the present invention from one aspect, there is provided a pump for use in pumping hydraulic well control fluid expelled from a control device of a well, comprising means for accumulating such hydraulic well control fluid and means for using the pressure of hydraulic fluid supplied to the well to pump accumulated hydraulic well control fluid into a production flowline of the well.

Preferably, said accumulating means comprises a cylinder arrangement including a piston, accumulated hydraulic well control fluid acting at one side of the piston for displacing the piston in a first direction, said means for using the pressure of hydraulic fluid supplied to the well applying pressure at the opposite side of said piston.

According to the present invention from another aspect, there is provided a pump for pumping hydraulic well control fluid expelled from a hydraulic control device of a well into a production flowline of the well, comprising:

a first cylinder arrangement, for accumulating such hydraulic well control fluid via a first inlet to the first cylinder arrangement;

a piston in the first cylinder arrangement, expelled well control fluid being accumulated on one side of the piston;

a second cylinder arrangement containing hydraulic fluid and in fluid communication with the first cylinder arrangement on the opposite side of the piston, wherein the pressure of expelled fluid accumulating in the first cylinder arrangement can cause said piston to be displaced in a direction towards the second cylinder arrangement, there being means for accommodating the displacement of hydraulic fluid in the second cylinder arrangement; and

a further inlet to the first cylinder arrangement on the opposite side of said piston for receiving hydraulic fluid supplied to the well, there being an outlet from the first cylinder arrangement on said first side of the piston for communicating with a production flowline of the well, the pump being such that if said piston has been displaced toward said second cylinder arrangement and if hydraulic fluid is applied to said further inlet at a pressure greater than the pressure of accumulated well control fluid in the first cylinder arrangement, said piston is displaced in a direction away from the second cylinder arrangement to displace accumulated well control fluid out of the first cylinder arrangement via said outlet.

There could be displacement means (such as a spool) received by said first cylinder arrangement between said piston and said further inlet, there being urging means (such as spring means in said second cylinder arrangement) for urging said displacement means in a direction towards the second cylinder arrangement, hydraulic fluid at said further inlet acting on said displacement means so that, if the pressure of hydraulic fluid at said further inlet is greater than pressure of accumulated well control fluid, said displacement means is displaced against the action of said urging means to displace said piston.

Each of said first inlet and said outlet is preferably provided with a one-way valve for permitting flow into and out of said first cylinder arrangement respectively.

Said second cylinder arrangement could comprise a first cylinder in fluid communication with said first cylinder arrangement and a second cylinder in fluid communication with said first cylinder, there being a further piston in said second cylinder, said accommodating means being in fluid communication with the side of said further piston remote from said first cylinder.

Said accommodating means could comprise an expandable container.

The pump could include means for sensing pressure of accumulated expelled hydraulic well control fluid to produce an indication for use in increasing the pressure of hydraulic fluid at said further inlet in response to the pressure of accumulated expelled hydraulic well control fluid reaching a particular value.

According to the present invention from another aspect, there is provided a method of pumping hydraulic well control fluid expelled from a control device of a well, comprising accumulating such hydraulic well control fluid and using the pressure of hydraulic fluid supplied to the well to pump accumulated hydraulic well control fluid into a production flowline of the well.

In an embodiment of the present invention, hydraulic power is supplied to a subsea well, typically from a surface source, via an umbilical, at a pressure of 280 bar. This is considerably less than the maximum pressure that the hydraulic system is able to handle. The pump to be described utilises a step increase, typically to 345 bar, of the hydraulic pressure fed to the well, to provide power to operate the pump, such that neither electric power nor a separate hydraulic power source is required. The pump also incorporates a storage system, adequate to contain the expelled fluid during a well shut down, which could result from electrical and /or hydraulic power failure, which is emptied on restoration of hydraulic power. Furthermore no hydraulic fluid is exhausted from the hydraulic operating mechanism of the pump, as the fluid is recycled.

Brief Description of the Drawings

Fig. 1 shows a pump according to an embodiment of the invention in a quiescent state;

Fig. 2 shows the pump having accumulated expelled hydraulic control fluid;

Fig. 3 shows the pump having pumped accumulated hydraulic control fluid into a production flowline of the well; and

Fig. 4 shows an alternative pump construction in the condition of having accumulated expelled hydraulic control fluid.

Detailed description of the Invention

Referring first to Fig. 1, which is a diagrammatic sectioned view of a pump in its quiescent position, i.e. ready to accept exhausted or expelled hydraulic fluid, an inlet port 1 is connected to the combined exhaust hydraulic control fluid outlets from hydraulic devices on a subsea well, such valve and choke actuators. When one or more hydraulic devices exhausts fluid, it passes via a non-return valve 2 into a void 3 within a cylinder 4 to be accumulated therein and push a free

running piston 5 to the right in the figure. A void 6 within the cylinder 4 is filled with hydraulic fluid and is the same fluid that fills cylinders 7 and 8 and a bladder 9. The movement of the piston 5 forces hydraulic fluid in the void 6 to pass through an orifice in the centre of displacement means in the form of a spool 10 (whose left-hand end in the figure is received in the cylinder 4) and into the cylinder 7 via a non-return valve 11, which is normally be closed for a flow in this direction, but is held open by a spigot 12. Fluid flow through the spool 10 forces a free running piston 13 in the cylinder 8 to move to the right in the figure, thereby forcing hydraulic fluid into the bladder 9, which expands appropriately.

The pump is fed with power by hydraulic fluid from the existing well hydraulic supply via a second inlet port 14 communicating with an umbilical of the well, to act upon the face of the spool 10 in the cylinder 4 and tends to push the spool 10 to the left in the figure. However, this is resisted by urging means in the form of a spring 15 in cylinder 7, whose compression force is adjusted to match the force applied by the well hydraulic power source. Thus, the spool 10 remains in position to the right in the figure, the spring compression being just enough to retain the spool 10 over the tolerance range of the normal operating pressure of the well hydraulic power source.

The void 3 is thus a storage or accumulation space for expelled hydraulic fluid from the operation of well control hydraulic devices, resulting in the piston 5 eventually moving as far to the right in the figure as it can, being stopped by the left-hand face in the figure of the spool 10, and fluid in the cylinder 8 being displaced into the bladder 9. This state is illustrated in Fig. 2. Further expelling or exhausting of hydraulic fluid into the inlet port 1 results in a rise in this inlet pressure, which is sensed by a pressure switch 16. Such a pressure switch 16 normally exists already on well hydraulic fluid exhaust systems and is connected electrically, via the well umbilical, to the well control centre at the surface, or on land, where the well hydraulic power source is also located. On receipt of a signal from the pressure switch, the control system step increases the hydraulic pressure at inlet port 14 from the source, i.e. typically, for example, from 280 bar to 345 bar.

Fig. 3 illustrates the result of this increased pressure, via the inlet port 14, acting on the right-hand face is the figure of the spool 10, producing a force greater than that applied by the spring 15, resulting in the spool 10 moving to the left in the figure and closing of the valve 11, since it is moved away from the spigot 12, and an increase of the pressure of the exhausted hydraulic fluid in the void 3 in the cylinder 4. An outlet port 17 of the pump houses a non-return valve 18 and is connected, via a pressure release valve, to an injection nozzle in the well production fluid flowline. The increase in pressure in the void 3 closes the inlet non-return valve 2, and when greater than the

pressure in the production fluid flowline, opens the non return valve 18, allowing accumulated fluid in the void 3 to be disposed of, by injection into the production fluid flowline, and resetting the pump to the quiescent state of Fig. 1.

If there is a failure of the hydraulic power supply fed to the inlet port 14, when the cylinder 4 is full of expelled hydraulic fluid, more hydraulic fluid will be available at the inlet port 1. This is able to enter an overflow cylinder 21, depressing a piston 22. The volume of the cylinder 21 is designed to be sufficient to handle all expelled hydraulic fluid resulting from a well shut down. On restoration of the hydraulic pressure at the inlet 14, the pressure switch 16 operates at the first exhaust of hydraulic fluid via the inlet 1, resulting in operation of the empty cycle by a step increase of pressure at the inlet 14. Reference numerals 23 designate holes which perforate the right-hand side in the figures of spool 10 to allow free movement of hydraulic fluid in the cylinder 7.

The maximum pressure that can be generated in the void 3 is approximately equal to the increase in hydraulic source pressure at the inlet port 14, when the internal diameter of the cylinder 4 is constant, and will be adequate to inject fluid into a production flowline whose pressure is less than this. Thus, the available pressure would be $345 \text{ bar} - 280 \text{ bar} = 65 \text{ bar}$ approximately. If the production flowline pressure is greater than this, the cylinder 4 could be replaced by two cylinders 19 and 20 as illustrated in Fig. 4. The ratio of the internal diameters of the cylinders 19 and 20 determines the final available pressure at the outlet 17. Thus, in the example, the outlet pressure will be $65 \text{ bar} \times (\text{diameter of cylinder 19} / \text{diameter of cylinder 20})$. The pump can therefore be designed either to handle the maximum known production flowline pressure or to suit a particular application. In practice, the ratio of the internal diameters of the cylinders 19 and 20 will have to be substantially greater than that simply calculated, as above, since the available force is reduced as the spring 15 compresses.

It should be noted that the cylinder 8 and its free running piston 13 are not essential components of this pump, since it will function correctly with the output of the cylinder 7 connected directly to the bladder 9. However, well operators prefer double isolation of a pump core from the external environment and, since the bladder provides only a single level of isolation from the environment, the cylinder 8 and piston 13 are included to provide a desired second level of isolation. Also, spring 15 could be replaced, for example, by the use of hydraulic pressure for urging spool 10 in a direction to the right in the figures.

Advantages of using the invention

The key advantage of the pump is that it does not require a separate source of power, and operates from a step increase of pressure from the existing well hydraulic power source. Further advantages are a) the hydraulic fluid used by the pump is not expelled or exhausted, but recycled back to its source when the step increase of pressure is reduced to normal operating pressure and b) exhausted or expelled hydraulic fluid from well actuators for example, resulting from a well electric and/or hydraulic power failure, is accommodated by the pump and disposed of by injection into the production flowline when hydraulic power is restored.

Claims:

1. A pump for use in pumping hydraulic well control fluid expelled from a control device of a well, comprising means for accumulating such hydraulic well control fluid and means for using the pressure of hydraulic fluid supplied to the well to pump accumulated hydraulic well control fluid into a production flowline of the well.
2. A pump according to claim 1, wherein said accumulating means comprises a cylinder arrangement including a piston, accumulated hydraulic well control fluid acting at one side of the piston for displacing the piston in a first direction, said means for using the pressure of hydraulic fluid supplied to the well applying pressure at the opposite side of said piston.
3. A pump for pumping hydraulic well control fluid expelled from a hydraulic control device of a well into a production flowline of the well, comprising:
 - a first cylinder arrangement, for accumulating such hydraulic well control fluid via a first inlet to the first cylinder arrangement;
 - a piston in the first cylinder arrangement, expelled well control fluid being accumulated on one side of the piston;
 - a second cylinder arrangement containing hydraulic fluid and in fluid communication with the first cylinder arrangement on the opposite side of the piston, wherein the pressure of expelled fluid accumulating in the first cylinder arrangement can cause said piston to be displaced in a direction towards the second cylinder arrangement, there being means for accommodating the displacement of hydraulic fluid in the second cylinder arrangement; and
 - a further inlet to the first cylinder arrangement on the opposite side of said piston for receiving hydraulic fluid supplied to the well, there being an outlet from the first cylinder arrangement on said first side of the piston for communicating with a production flowline of the well, the pump being such that if said piston has been displaced toward said second cylinder arrangement and if hydraulic fluid is applied at said further inlet at a pressure greater than the pressure of accumulated well control fluid in the first cylinder arrangement, said piston is displaced in a direction away from the second cylinder arrangement to displace accumulated well control fluid out of the first cylinder arrangement via said outlet.
4. A pump according to claim 3, wherein there is displacement means between said piston and said further inlet, there being urging means for urging said displacement means in a direction towards the second cylinder arrangement, hydraulic fluid at said further inlet acting on said

displacement means so that if the pressure of hydraulic fluid at said further inlet is greater than pressure of accumulated well control fluid, said displacement means is displaced against the action of said urging means to displace said piston.

5. A pump according to claim 4, wherein said displacement means comprises a spool received by said first cylinder arrangement between said piston and said further inlet.

6. A pump according to claim 4 or 5, wherein said urging means comprises spring means in said second cylinder arrangement.

7. A pump according to any of claims 3 to 6, wherein each of said first inlet and said outlet is provided with a one-way valve for permitting flow into and out of said first cylinder arrangement respectively.

8. A pump according to any of claims 3 to 7, wherein said second cylinder arrangement comprises a first cylinder in fluid communication with said first cylinder arrangement and a second cylinder in fluid communication with said first cylinder, there being a further piston in said second cylinder, said accommodating means being in fluid communication with the side of said further piston remote from said first cylinder.

9. A pump according to any of claims 3 to 8, wherein said accommodating means comprises an expandable container.

10. A pump according to any of claims 3 to 9, including means for sensing pressure of accumulated expelled hydraulic well control fluid to produce an indication for use in increasing the pressure of hydraulic fluid at said further inlet in response to the pressure of accumulated expelled hydraulic well control fluid reaching a particular value.

11. A method of pumping hydraulic well control fluid expelled from a control device of a well, comprising accumulating such hydraulic well control fluid and using the pressure of hydraulic fluid supplied to the well to pump accumulated hydraulic well control fluid into a production flowline of the well.