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A Method of Operating A Valve and A System for Wellbore Operations

Field of the Invention

The present invention relates to a method of operating a valve and a system for wellbore operations.

Background of the Invention

When performing wellbore operations downhole, it is necessary to first make up a tool string at the surface of the wellbore prior to lowering that tool string downhole for performing the wellbore operations. In the past, the length of the tool string was limited by the maximum height of surface equipment and a longer tool string length was often desired. Therefore, when the tool string performed the wellbore operations downhole, that tool string was raised uphole and another, second tool string was made up at the surface of the wellbore. The second tool string was lowered downhole for performing additional wellbore operations. However, it is time consuming and expensive to continually make up additional tool strings at the wellbore surface, following the performance of the initial wellbore operation by the first tool string, and sequentially lower those additional tool strings downhole for performing additional wellbore operations. It would be desirable to make up one tool string having the desired length at the wellbore surface and to lower that desired tool string downhole for performing a wellbore operation during one trip into the wellbore. For example, when the tool strings include perforating guns, in the past, it was necessary to implement the following perforating procedure when perforating long length intervals of a wellbore: perforate the long length interval during multiple trips into the wellbore by making up, at the wellbore surface, a first perforating gun having a limited first length, lowering the first perforating gun downhole, perforating a formation penetrated by the wellbore, raising the first perforating gun uphole (or dropping that perforating gun to the bottom of the wellbore), making up a second perforating gun having another

second limited length at the wellbore surface, lowering the second perforating gun downhole, perforating another section of the formation, raising the second perforating gun uphole (or dropping it to a bottom of the wellbore), etc. The above referenced perforating procedure is time consuming and costly.

As a result, it became necessary to design a method and apparatus for creating a tool string, of any desired length, uphole at the surface of the wellbore, so that the tool string may be lowered downhole and wellbore operations performed downhole during only one trip into the wellbore.

U.S. Patent 5,509,481 to Huber et al discussed one method for perforating long length intervals of a formation during a single run into the wellbore. The Huber apparatus disclosed an automatic release apparatus which would disconnect one part of a long gun string from a second part of the gun string just before the perforating guns of that gun string would detonate.

Another prior pending application also discloses a method and apparatus for making up, at the wellbore surface, a tool string of any desired length prior to lowering that tool string downhole for performing a wellbore operation in the wellbore during one trip into the wellbore. In a prior application entitled "Completions Insertion and

Retrieval Under Pressure (CIRP) Apparatus including the Snaplock Connector", having a United States Serial Number of 08/638,001 and filed on April 25, 1996

and corresponding to a prior filed provisional application number 60/010,500 filed January 24, 1996 (hereinafter, the "CIRP application"), a tool string of any desired length is built uphole prior to lowering that tool string downhole by first holding a first tool, having a first and a second section of a snaplock connector connected

thereto, in a deployment BOP or snaplock operator while suspending a second tool, also having a third section of the snaplock connector connected thereto, by wireline in a lubricator. The second tool is lowered down through the lubricator and through a master valve by operating a winch until the third section of the snaplock connector on the second tool connects to the second section of the snaplock connector on the first tool thereby forming a first tool string having a length which corresponds to the first tool and the second tool. The hold by the deployment BOP is released from the first tool, the first tool string is lowered, and the deployment BOP grips the second tool. The second tool also includes another first, second, and third section of a snaplock connector connected to its opposite side, the third section (called a deployment stinger) being connected to the wireline. The deployment stinger is raised uphole by operating the winch, and it is replaced by a third tool, such as a firing head, which also includes a third section of a snaplock connector. The third tool suspends by the wireline in the lubricator and it is lowered downhole and attached to the second tool being held by the deployment BOP. The hold by the deployment BOP on the second tool is released, and a resultant tool string of the desired length, consisting of the first tool, the second tool, and the third tool, is lowered downhole for the purpose of performing wellbore operations downhole during one trip into the wellbore.

However, another alternate apparatus, and corresponding method, is needed for isolating the formation downhole by means of closing a valve so that wellhead pressure can be bled off for building a long tool string uphole of any desired length and lowering that tool string downhole without a need for snubbing under wellhead pressure for the purpose of performing wellbore operations downhole during a single trip into the wellbore.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a method of operating a valve in a wellbore, comprising:

- moving a medium from a medium reservoir through a flowline and into a first
5 chamber of the valve;
- exerting a pressure by the medium against a piston of the valve and moving a mandrel in one direction in response thereto;
- metering the medium from the first chamber through a metering orifice in the piston and into a second chamber of the valve;
- 10 operating said valve by changing a state of the valve from a first state to a second state in response to the movement of said mandrel in said one direction;
- exerting a pressure by the medium in said second chamber against said piston;
- metering said medium from said second chamber through said metering orifice into said first chamber through said flowline and through a fast bleed valve;
- 15 moving said mandrel in a direction opposite to said one direction; and
- operating said valve by changing said state of the valve from said second state to said first state in response to the movement of said mandrel in said direction opposite to said one direction.

In another aspect, there is provided a system adapted for use in connection with wellbore
20 operations, comprising:

- an outer housing;
- a mandrel enclosed by the outer housing and movable longitudinally within said outer housing;
- a piston on said mandrel and a metering orifice longitudinally disposed through
25 said piston; said mandrel and said housing defining a first chamber on one side of the piston and a second chamber on another side of the piston; and
- a valve manifold and a flowline interconnecting said valve manifold to said first chamber.

Preferably, the system further comprises a reservoir, said flowline interconnecting said
30 reservoir to said first chamber.

Preferably, said valve manifold comprises a fast bleed valve and a slow bleed valve,
one of said fast bleed valve and slow bleed valve adapted to be selectively
interconnected to said first chamber via said flowline.

Further scope of applicability of the present invention will become apparent from the detailed description presented hereinafter. It should be understood, however, that the detailed description and the specific examples, while representing a preferred embodiment of the present invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become obvious to one skilled in the art from a reading of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

A full understanding of the present invention will be obtained from the detailed description of the preferred embodiment presented hereinbelow, and the accompanying drawings, which are given by way of illustration only and are not intended to be limitative of the present invention, and wherein:

figure 1 illustrates a tubing string including a valve in accordance with the present invention and a coiled tubing or wireline conveyed perforating gun running through the full bore of the tubing string and through the valve and running downhole into a deviated wellbore, a gas reservoir and a valve manifold being disposed at a surface of the wellbore;

figure 2 illustrates a more detailed construction of the valve manifold of figure 1; and

figures 3 and 4 illustrate a more detailed construction of the valve of figure 1 in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to figure 1, a tubing string 12 having a full bore is disposed in a partially deviated wellbore consisting of a vertical wellbore 13 and a deviated wellbore 15. The tubing string 12 includes a valve 18 which is disposed in the vertical wellbore 13 portion of the partially deviated wellbore. The valve 18 includes a ball valve 18a which is rotatable between a closed position, for closing off the full bore of the tubing string 12 thereby preventing fluid communication within the tubing string 12 between the vertical wellbore 13 and the deviated wellbore 15, and an open position for opening and allowing fluid communication within the tubing string 12 between the vertical wellbore 13 and the deviated wellbore 15. In figure 1, a tubing 14, such as coiled tubing 14, having a perforating gun 10 suspending from the lower end of the coiled tubing 14, is disposed within the tubing string 12 and within both the vertical wellbore 13 and the deviated wellbore 15 of the partially deviated wellbore when the ball valve 18a is disposed in the open position. When the coiled tubing 14 is disposed within the tubing string 12 as shown in figure 1, an annulus space 22 located above the ball valve 18a is defined between the coiled tubing 14 and the tubing string 12. However, when the coiled tubing 14 is not disposed within the tubing string 12 as shown in figure 1, a full bore space 22 is located above the ball valve 18a within the tubing string 12. As mentioned later, when the ball valve 18a is closed, this full bore space 22 can be used to build a new tool string uphole of any desired length. In the vertical wellbore 13 of figure 1, the tubing string 12 does not form part of the casing of the wellbore; however, in the deviated wellbore 15 of figure 1, the tubing string 12 forms the casing in the deviated wellbore.

In figure 1, the valve 18, which is situated downhole, is connected to a gas reservoir 24 (a nitrogen bottle 24) and a valve manifold 26, each of which are separately situated at the surface of the wellbore. A gas is stored in the gas reservoir 24, the gas flowing between the gas reservoir 24/valve manifold 26 at the wellbore surface and the valve 18 located downhole in the wellbore via a flowline 17. The flowline 17 is a one-quarter inch (1/4") pipe situated between the tubing string 12 and a casing 19 in the vertical wellbore 13 and connected between a control line 18c of the valve 18 (see figure 3) and the gas reservoir 24/valve manifold 26 situated at the surface of the wellbore. The gas reservoir 24 is really a nitrogen bottle which stores a gas, such as nitrogen, and the valve manifold 26 includes a pair of bleed valves (a slow bleed valve and a fast bleed valve) which are more particularly shown in figure 2. The gas in the gas reservoir 24 uphole communicates with the valve 18 downhole. When the gas in the gas reservoir 24 has been communicated to the valve 18, that same gas in the valve 18 can then be re-communicated back to the bleed valves of the valve manifold 26, a process which will be described in more detail below in this specification.

Referring to figure 2, the valve manifold 26 includes a slow bleed valve 26a and a fast bleed valve 26b. As the names imply, the slow bleed valve 26 will allow a gas to pass (bleed) very slowly therethrough, whereas the fast bleed valve 26b will allow a gas to pass (bleed) very rapidly therethrough. The function of these bleed valves 26a, 26b will be set forth below in the functional description of the operation of the present invention.

In operation, referring to figure 1, the ball valve 18a is open and the perforating gun 10 with associated coiled tubing 14 is situated in the wellbore as shown in figure 1, the perforating gun 10 perforating the formation penetrated

by the deviated wellbore 15 thereby forming a plurality of perforations 20 in the deviated wellbore 15. When the perforating gun 10 has perforated the deviated wellbore 15, the coiled tubing 14 and the perforating gun 10 are raised uphole until the perforating gun 10 passes through the ball valve 18a of the valve 18, at which point, the perforating gun 10 and associated coiled tubing 14 are located above the valve 18 within the tubing string 12 in the vertical wellbore 13. The ball valve 18a is then closed. When the ball valve 18a is closed, the perforating gun 10 is raised uphole to a surface of the wellbore, leaving empty the full bore space 22 which is located above the closed ball valve 18a within the tubing string 12. A new tool string of any desired length (the length of the new tool string being limited only by the distance between the ball valve 18a and the wellbore surface) may then be built within the full bore space 22. When the new tool string is built within the full bore space 22, the ball valve 18a is reopened, and the new tool string is lowered downhole for the purpose of performing other wellbore operations downhole.

Referring to figures 3 and 4, a detailed construction of the valve 18 of the present invention is illustrated.

In figures 3 and 4, the valve 18 of the present invention, adapted for deploying a desired length of a tool string in a wellbore, includes an outer housing 18b. The outer housing 18b further includes an open port 18c, otherwise known as a control line 18c, which is connected to the flowline 17, the one-quarter inch pipe 17 that is connected to the gas reservoir 24 and the valve manifold 26 at the surface of the wellbore. The gas in the gas reservoir 24 can communicate with the control line 18c of the valve 18 via the flowline pipe 17, and the gas in the valve 18 can communicate with the bleed valves 26a, 26b of the valve manifold 26 via the control line 18c of the valve 18 and the flowline pipe 17.

The valve 18 of figures 3 and 4 further include a mandrel 18d connected to the ball valve 18a and enclosed by the outer housing 18b. The mandrel 18d is further connected to a piston 18e, and the piston 18e separates an upper gas chamber 18f from a lower gas chamber 18g. The upper gas chamber 18f is defined by the mandrel 18d, an upper part of the piston 18e and the outer housing 18b, whereas the lower gas chamber 18g is defined by the mandrel 18d, a lower part of the piston 18e, and the outer housing 18b. The piston 18e includes a gas metering orifice 18e1 disposed through the axial center of the piston 18e. The gas metering orifice 18e1 allows a gas, such as nitrogen, from the gas reservoir 24, to be metered slowly between the upper gas chamber 18f and the lower gas chamber 18g, for reasons which will be described later in this specification. A spring biased ratchet 18h is biased inwardly by a spring, as shown in figures 3 and 4, the ratchet 18h adapted to be received in one of two detents 18d1 and 18d2 in the mandrel 18d, the detents 18d1, 18d2 each being a groove which is carved into the mandrel 18d and which is adapted to receive the ratchet 18h.

A functional description of the operation of the surface controlled formation isolation valve of the present invention, adapted for deploying a desired length of a tool string in a wellbore, will be set forth in the following paragraphs with reference to figures 1 through 4 of the drawings.

The perforating gun 10 of figure 1 perforates the formation 15 and produces a plurality of perforations 20 in the formation 15. An operator at the wellbore surface of figure 1 raises the coiled tubing 14 uphole. Since the perforating gun 10 is connected to the coiled tubing 14, the perforating gun 10 also is raised uphole in figure 1. Since the ball valve 18a of the valve 18 is open, the perforating gun 10

will pass through the full bore center of the valve 18. When the perforating gun 10 is removed from the full bore space 22 of the vertical wellbore 13, the valve 18 must now be closed so that a tool string of desired length may be built inside the full bore space 22 which is situated above the closed ball valve 18a in the vertical wellbore 13.

In order to close the ball valve 18a, referring to figures 1, 2, and 3, assume that the gas pressure within the upper gas chamber 18f is equal to the gas pressure within the lower gas chamber 18g. The gas present in the upper gas chamber 18f is allowed to flow through the control line 18c, through the flowline pipe 17, and into the valve manifold 26 of figure 1 for the purpose of closing the ball valve 18a. In the valve manifold 26, the gas flows into the fast bleed valve 26b of figure 2. As a result, the gas will flow from the upper gas chamber 18f, through flowline 17, and through the fast bleed valve 26b at a rate which is faster than the rate at which the gas in the lower gas chamber 18g can meter through the gas metering orifice 18e1 into the upper gas chamber 18f. Therefore, the gas pressure inside the upper gas chamber 18f will be less than the gas pressure inside the lower gas chamber 18g and, as a result, the piston 18e and the mandrel 18d move upwardly in figure 3. The ball valve 18a closes. Eventually, the gas pressure inside the upper gas chamber 18f and the lower gas chamber 18g falls to a value which is approximately equal to zero. The closed ball valve 18a is shown in figure 4.

With the ball valve 18a closed, another, new tool string of desired length is built inside the full bore space 22 located above the closed ball valve 18a in figure 1.

When the new tool string is built in the full bore space 22, the ball valve 18a must now be re-opened so that the new tool string can be lowered downhole, from its current

location in the full bore space 22, for the purpose of performing a new wellbore operation downhole.

The ball valve 18a is re-opened in the following manner: referring to figures 1 and 4, a gas, such as Nitrogen, from the gas reservoir 24, is forced to flow from the reservoir 24, through the flowline pipe 17, through the control line 18c in figure 3, and into the upper gas chamber 18f. The gas is exerted against the piston 18e, and it begins to meter slowly through the gas metering orifice 18el into the lower gas chamber 18g. However, since there is no gas within the lower gas chamber 18g, the piston 18e moves downwardly in figure 4 which, in turn, moves the mandrel 18d downwardly and which re-opens the ball valve 18a, as shown in figure 3. Eventually, the gas in the upper gas chamber 18f flows through the metering orifice 18el into the lower gas chamber 18g. As a result, when the ball valve 18a is re-opened, the gas pressure in the upper gas chamber 18f equals the gas pressure in the lower gas chamber 18g.

At this point, now that the ball valve 18a is reopened, the new tool string can be lowered downhole, from its current location in the full bore space 22, and through the ball valve 18a, for the ultimate purpose of performing a new wellbore operation downhole.

In figures 1, 2 and 3, the gas in the lower gas chamber 18g of figure 3 can flow into the upper gas chamber 18f, and the gas in the upper gas chamber 18f in figure 3 can flow through the flow line pipe 17 and into valve manifold 26 without reclosing the ball valve 18a as previously recited. To accomplish this without reclosing the ball valve 18a, in figure 3, the gas in the upper gas chamber 18f will flow into the flowline pipe 17, and into the slow bleed valve 26a of the valve manifold 26 of figure 2 (the gas does not flow into the fast bleed valve 26b). As a result, since the gas

flows into the slow bleed valve 26a, the rate at which the gas flows from the upper gas chamber 18f and through the slow bleed valve 26a is lower than the rate at which the gas in the lower gas chamber 18g flows through the gas metering orifice 18e1 and into the upper gas chamber 18f.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.



CLAIMS

1. A method of operating a valve in a wellbore, comprising:
 - moving a medium from a medium reservoir through a flowline and into a first chamber of the valve;
 - 5 exerting a pressure by the medium against a piston of the valve and moving a mandrel in one direction in response thereto;
 - metering the medium from the first chamber through a metering orifice in the piston and into a second chamber of the valve;
 - operating said valve by changing a state of the valve from a first state to a second
 - 10 state in response to the movement of said mandrel in said one direction;
 - exerting a pressure by the medium in said second chamber against said piston;
 - metering said medium from said second chamber through said metering orifice into said first chamber through said flowline and through a fast bleed valve;
 - moving said mandrel in a direction opposite to said one direction; and
 - 15 operating said valve by changing said state of the valve from said second state to said first state in response to the movement of said mandrel in said direction opposite to said one direction.
2. A system adapted for use in connection with wellbore operations, comprising:
 - 20 an outer housing;
 - a mandrel enclosed by the outer housing and movable longitudinally within said outer housing;
 - a piston on said mandrel and a metering orifice longitudinally disposed through said piston; said mandrel and said housing defining a first chamber on one side of the
 - 25 piston and a second chamber on another side of the piston; and
 - a valve manifold and a flowline interconnecting said valve manifold to said first chamber.
3. The system of claim 2, further comprising:
 - 30 a reservoir, said flowline interconnecting said reservoir to said first chamber.



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4. The system of claim 3, wherein said valve manifold comprises a fast bleed valve and a slow bleed valve,

one of said fast bleed valve and slow bleed valve adapted to be selectively interconnected to said first chamber via said flowline.

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