A method for reverse cementing may include providing a valve having a sliding sleeve, an outer sleeve situated about at least a portion of the sliding sleeve and connected to a casing string, and a spring configured to position the valve in an open position. The method may also include: running the casing string and valve into a well bore while the valve is in an open position; reverse cementing, while the valve is in an open position; and closing the valve after reverse cementing by allowing the valve to contact the well bore.
REVERSE CIRCULATION CEMENTING VALVE

BACKGROUND

[0001] Typically, after a well for the production of oil or gas has been drilled, casing is lowered and cemented into the well bore. Normal primary cementing of the casing string in the well bore includes lowering the casing to a desired depth and displacing a desired volume of cement down the inner diameter of the casing. Cement is displaced downward into the casing until it exits the bottom of the casing into the annular space between the outer diameter of the casing and the well bore apparatus. This method may present numerous challenges, including difficulty getting circulation inside of the annular space due to weak formations. Not only does the hydrostatic weight of the cement exert pressure against formations, but additional pressure is applied to formations due to the friction of the fluid that must be overcome.

[0002] One method to help reduce the formation pressure is to pump fluids down the annulus and back up through the casing, often called “reverse circulation” or “reverse cementing.” The reverse-cementing method comprises displacing conventionally mixed cement into the annulus between the casing string and the annulus between an existing string, or an open hole section of the well bore. As the cement is pumped down the annular space, drilling fluids ahead of the cement are displaced around the lower ends of the casing string and up the inner diameter of the casing string and out at the surface. The fluids ahead of the cement may also be displaced upwardly through a work string that has been run into the inner diameter of the casing string and sealed off at its lower end. Because the work string has a smaller inner diameter, fluid velocities in the work string will be higher and will more efficiently transfer the cuttings washed out of the annulus during cementing operations. To ensure that a good quality cement job has been performed, a small amount of cement will be pumped into the casing and the work string. As soon as a desired amount of cement has been pumped into the annulus, the work string may be pulled out of its seal receptacle and excess cement that has entered the work string can be reverse-circulated out the lower end of the work string to the surface.

[0003] Reverse cementing, as opposed to the conventional method, provides a number of advantages. For example, cement may be pumped until a desired quality of cement is obtained at the casing shoe. Furthermore, cementing pressures are much lower than those experienced with conventional methods and cement introduced in the annulus flows down the annulus, producing little or no pressure on the formation. Oil or gas in the well bore ahead of the cement may be bled off through the casing at the surface. Finally, when the reverse-cementing method is used, less fluid is required to be handled at the surface and cement returners may be utilized more efficiently.

[0004] While reverse-cementing can greatly reduce the total pressure applied to the formation, it has some drawbacks. First, it is difficult to know exactly when the cement has been circulated into the casing. In some instances a wire line tool is placed downhole to determine when radioactive tracers or changes in fluid properties occur, thus providing an indication of when the cement has completely filled the annulus and began to enter the casing. Another technique is to use a volumetric method involving the monitoring of fluid volumes returning to the surface and estimating when the cement has filled the annulus. If, however, this method is attempted while cementing an annulus between the casing and formation that been drilled out, there can be a large uncertainty about the actual annular hole volume. This may result in incomplete filling of the annulus with cement, or it may result in overfilling the annulus and getting cement back up inside the casing string. This cement inside the casing string may cover potential productive zones and/or require additional rig time to drill out. Another challenge to reverse circulation is the problem of effective float equipment that keeps the typically heavier cement from flowing inside the casing due to U-Tubing. Because the fluids are pumped reverse, conventional float equipment cannot be used. This means that after a reverse cement job, pressure must be held on the inside of the casing until the cement has sufficiently set to prevent this U-Tubing. This can cause a micro-annulus to form between the cement sheath and casing, which makes it difficult to bond the casing to evaluate the quality of the cement job and determine if the annulus is properly sealed.

SUMMARY

[0005] The present invention relates generally to reverse cementing. More specifically, the present invention is directed to a valve that may be used in reverse cementing operations.

[0006] In one embodiment of the present invention, a method for reverse cementing comprises: providing a valve comprising a sliding sleeve, an outer sleeve situated about at least a portion of the sliding sleeve and connected to a casing string, and a spring configured to position the valve in an open position. The method of this embodiment further comprises: running the casing string and valve into a well bore while the valve is in an open position; reverse cementing, while the valve is in an open position; and closing the valve after reverse cementing by allowing the valve to contact the well bore.

[0007] In another embodiment of the present invention, a valve for reverse cementing comprises: a sliding sleeve having one or more openings; a nose attached to a sliding sleeve; an outer sleeve situated about at least a portion of the sliding sleeve; and a spring configured to position the sliding sleeve such that fluid may pass through the openings.

[0008] In still another embodiment of the present invention, a method for reverse cementing comprises: providing a valve comprising a sliding sleeve, an outer sleeve situated about at least a portion of the sliding sleeve and connected to a casing string. The method of this embodiment further comprises: running the casing string and valve into a well bore while the valve is in a closed position; opening the valve after running the casing string by allowing the valve to contact the well bore; reverse cementing, while the valve is in an open position; and closing the valve after reverse cementing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a side view of a valve in accordance with one embodiment of the present invention.

[0010] FIG. 2 is a side view showing another embodiment of the valve in accordance with the present invention.

DETAILED DESCRIPTION

[0011] Referring now to FIGS. 1 and 2, valve 100 may be used in reverse cementing applications. More specifically, valve 100 may be attached at or near the bottom of casing string 102 via threaded connection or otherwise. Valve 100
may be operated by simply lowering casing string 102 until casing string 102 contacts a lower end of well bore 106. This contact causes the weight of casing string 102 to activate valve 100. This involves sliding sleeve 108 of valve 100 moving relative to outer sleeve 118 of valve 100. Depending on the application, this may open ports 116, allowing fluid to flow from within casing string 102 to annulus 104 and vice versa, or it may close ports 116, preventing the flow of fluid therethrough.

Valve 100 may include outer sleeve 118, which may have threads 130 near an upper end for securing outer sleeve 118 to casing string 102. Outer sleeve 118 and threads 130 may be sized such that valve 100 may fit any of a number of different casing strings, depending on the specific circumstances of the site. Therefore valve 100 may be a shoe.

Additionally, valve 100 may include sliding sleeve 108 situated at least partially within outer sleeve 118. Sliding sleeve 108 may be moveable longitudinally with respect to outer sleeve 118. Sliding sleeve 108 may include nose 110 at an end opposite outer sleeve 118. Nose 110 may be constructed such that it guides valve 100 into well bore 106, without activating, yet easily activates valve 100 when reaching the bottom of well bore 106. For example, nose 110 may have a conical, rounded or other suitable shape. Since drilling of the well bore 106 does not necessarily stop at the exact point where casing string 102 ends, it may be desirable to construct at least a portion of valve 100 of drillable materials. For example sliding sleeve 108, including nose 110 may be made of drillable materials, such as composites, phenolics, metallics, or plastics, or any other drillable material. While drillable materials may be desirable in certain applications, they would not be necessary when drilling stops at the bottom of the casing string 102.

Valve 100 may also include spring 120, which may be a standard spring or any other type of compression member tending to bias sliding sleeve 108 out of outer sleeve 118. Spring 120 may be constructed of materials suitable for use in a typical downhole environment. In the embodiment shown in FIG. 2, however, spring 120 is contained between sliding sleeve 108 and outer sleeve 118 and sealed from annulus 104. This may allow spring 120 to compress freely without being limited by contaminants. Additionally, it may prevent rust or other reactions with fluids present in annulus 104.

Valve 100 may also include one or more seals 126 to reduce or eliminate leakage through the valve. Seals 126 may be o-rings or any type of seal used in a downhole environment.

Since well bore 106 is not cased until after valve 100 has passed through, valve 100 may include centralizer 128. Centralizer 128 may prevent nose 110 from catching on the formation prior to reaching the bottom. Thus, centralizer 128 may help to prevent premature activation.

Valve 100 also includes one or more ports 116 configured to selectively allow fluid to flow from annulus 104 into casing string 102. In the embodiment of FIG. 1, ports 116 include flow passages 112 in outer sleeve 118, which may align with openings 114 in sliding sleeve 108, creating a passage therethrough. In this embodiment, flow passages 112 in the outer sleeve 118 must be aligned with openings 114 in sliding sleeve 108, or ports 116 will be closed. Alternatively, in the embodiment of FIG. 2, ports 116 only include openings 114 in sliding sleeve 108, with no corresponding flow passages in outer sleeve 118. This embodiment allows ports 116 to be open, so long as ports 116 are not obstructed by outer sleeve 118. Openings 114 and flow passages 112 may be holes, slots, or any other type of opening allowing the passage of fluid therethrough. Openings 114 and flow passages 112 may be radial to moveable sleeve 108 and casing string 102, or they may tilt, depending on the specific application. Additionally, the shape and/or orientation of openings 114 may differ from the shape and/or orientation of flow passages 112. In some circumstances, the total cross sectional area of ports 116 may be approximately equal to the cross sectional area of casing string 102. However, one of ordinary skill in the art will appreciate that the total cross sectional area of ports 116 may be larger or smaller than the cross sectional area of casing string 102. In some applications, the minimum diameter of ports 116 may be about 1/4" and the maximum diameter of ports 116 may be several inches. In other applications, the minimum diameter of ports 116 may be about 1/2" and the maximum diameter of ports 116 may be 1 1/2". While circular ports 116 are disclosed, the ports 116 may be any shape.

In the embodiments shown, ports 116 are closed when spring 120 is compressed, such that at least a portion of sliding sleeve 108 moves into outer sleeve 118. As this happens, ports 116 close. In the embodiment of FIG. 1, this happens when flow passages 112 are no longer aligned with openings 114. In the embodiment of FIG. 2, this happens when the portion of sliding sleeve 108 containing openings 114 moves into outer sleeve 118. Spring 120 may be compressed by weight on casing string 102. More particularly, after nose 110 makes contact with the bottom of well bore 106, and casing string 102 continues to be lowered, spring 120 compresses, resulting in relative movement between sliding sleeve 108 and outer sleeve 118. In some embodiments, removal of the compressing force on spring 120 will result in ports 116 reopening.

Referring now to FIG. 2, as an alternative to reopening when weight is removed, at least one latch mechanism may be provided to maintain ports 116 in a closed position. Latch mechanism may be any device or mechanism for preventing relative movement between sliding sleeve 108 and outer sleeve 118. For example, but not by way of limitation, the latch mechanism may include a spring loaded pin 122, which engages groove 124. As spring 120 is compressed and ports 116 are closed, pin 122 may align with groove 124. At least a portion of pin 122 may engage groove 124, preventing sliding sleeve 108 from moving relative to outer sleeve 118. In the embodiment of FIG. 2, pin 122 is shown in sliding sleeve 108 and groove 124 is shown in outer sleeve 118. However, pin 122 and groove 124 could be placed in opposite locations, or in any location that may prevent relative movement between sliding sleeve 108 and outer sleeve 118.

When pin 122 and groove 124 are used, ports 116 may be reopened by applying pressure on the inside of casing string 102. This pressure will push downward on sliding sleeve 108 relative to outer sleeve 118. While pin 122 and groove 124 may have a tendency to prevent movement, sufficient pressure may cause pin 122 to retract from groove 124, and thus allow sliding sleeve 108 to move relative to outer sleeve 118, until ports 116 are reopened. Therefore, pin 122 may be rounded or otherwise shaped such that it does not completely and irreversibly engage groove 124. Likewise, any other latch mechanism used may be constructed such that it can be released without damage.

When casing string 102 and attached valve 100 are being run into well bore 106, ports 116 may be held in an open position by spring 120, allowing mud or other fluid to flow
freely from annulus 104 into and through casing string 102. This is known as “auto flow” and prevents casing string 102 from floating in the mud.

In some instances, it may be useful to reopen ports 116 that have inadvertently closed. This may occur in any number of cases. For example, nose 110 may “catch” on well bore 106 at a point above the bottom. In one embodiment, ports 116 may be reopened by simply removing weight from casing string 102. In another embodiment, reopening ports 116 involves the application of pressure to the inside of casing string 102.

After valve 100 reaches the bottom of well bore 106, weight on casing string 102 may cause ports 116 to close, verifying that valve 100 has reached the bottom. After ports 116 have closed as a result of valve 100 reaching the bottom of well bore 106, ports 116 may be reopened. Fluids may be circulated in either the conventional or reverse directions when ports 116 are open. Ports 116 may remain open until cement is reverse circulated in place. At the end of the circulation of cement, casing string 102 and valve 100 may again be lowered until spring 120 compresses and ports 116 are closed. In one embodiment, pin 122 then engages groove 124 such that ports 116 remain closed. This may allow for optimum bonding of the cement to casing string 102. Additionally, it may allow normal surface operations to take place while waiting for the cement to set.

One of ordinary skill in the art will appreciate that the elements for use in the embodiments described above may be used in a manner that allows weight on casing string 104 to cause ports 116 to open. In other words, weight may cause sliding sleeve 108 to move, such that ports 116 are open. Optional pins (not shown) may be used to keep the ports 116 open. Ports 116 may then be closed by removing the weight of casing string 102. Alternatively, ports 116 may be closed by doing a weight shift cycle on and off. Yet another alternative is to close ports 116 with a “bomb” that is dropped allowing for a pressurizing. Thus, a method for reverse cementing may include: providing valve 100 including sliding sleeve 108, outer sleeve 118 situated at least a portion of sliding sleeve 108 and connected to casing string 102, and spring 120 configured to position valve 100 in an open position. This method may also include: running casing string 102 and valve 100 into well bore 106 while valve 100 is in an open position; reverse cementing, while valve 100 is in an open position; and closing valve 100 after reverse cementing by one of several methods. The methods of closing valve 100 may include, for example, setting weight down on casing string 102 to close ports 116 or dropping a weighted plug (not shown) that then can have pressure applied to close ports 116.

An alternative method for reverse cementing may include: providing valve 100 including sliding sleeve 108, outer sleeve 118 situated about at least a portion of sliding sleeve 108 and connected to casing string 102. This method may also include: running casing string 102 and valve 100 into well bore 106 while valve 100 is in an open position; reverse cementing, while valve 100 is in an open position; and closing valve 100 after reverse cementing by dropping a weighted dart/bomb (not shown) that can engage a closing mechanism (not shown) and then applying pressure to move sliding sleeve 108 downward and close valve 100.

Valve 100 may be used in conjunction with wire line tools and various fluid tags. Valve 100 may also be used by pumping a tracer fluid ahead of the cement job. The tracer fluid can be identified at the surface to determine when cement slurry, some distance behind the leading edge of the tracer, will be entering casing string 102. Valve 100 may also be used with a simple volumetric method of pumping a predetermined amount of fluid and stopping.

A variation of valve 100 may also be placed some distance above the bottom of a tubing string assembly, allowing for circulation of cement to a predetermined depth, and leaving well bore 106 below free of cement.

One may also drill well bore 106 past a target production zone, set casing below the target production zone, and then allow for cement to circulate up into the casing, but not up across production zones. This may reduce or eliminate the need to drill out cement at the bottom for the casing string, if the method were used on a final production casing cement job.

Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

What is claimed is:

1. A method for reverse cementing, comprising:
   providing a valve comprising a sliding sleeve, an outer sleeve situated at least a portion of the sliding sleeve and connected to a casing string, and a spring configured to position the valve in an open position;
   running the casing string and valve into a well bore while the valve is in an open position;
   reverse cementing, while the valve is in an open position;
   and closing the valve after reverse cementing by allowing the valve to contact the well bore.

2. The method for reverse cementing of claim 1, wherein closing the valve after reverse cementing comprises allowing the valve to contact the bottom of the well bore.

3. The method for reverse cementing of claim 1, further comprising:
   pumping a tracer fluid ahead of the cement.

4. The method for reverse cementing of claim 1, further comprising:
   allowing the cement to bond to the casing string.

5. The method for reverse cementing of claim 1, further comprising:
   closing the valve prior to reverse cementing by allowing the valve to contact the well bore; and
   reopening the valve prior to reverse cementing.

6. The method for reverse cementing of claim 5, wherein closing the valve prior to reverse cementing comprises allowing the valve to contact the bottom of the well bore.

7. The method for reverse cementing of claim 5, wherein the valve further comprises a latch mechanism and wherein reopening the valve comprises applying pressure on the inside of the casing string.

8. The method for reverse cementing of claim 5, wherein reopening the valve comprises removing weight from the casing string.
9. A valve for reverse cementing, comprising:
   a sliding sleeve having one or more openings;
   a nose attached to sliding sleeve;
   an outer sleeve situated about at least a portion of the
   sliding sleeve; and
   a spring configured to position the sliding sleeve such that
   fluid may pass through the openings.
10. The valve for reverse cementing of claim 9, further comprising:
    one or more flow passages in the outer sleeve;
    wherein the spring is further configured to align the open-
    ings of the sliding sleeve with the flow passages of the
    outer sleeve such that fluid may pass therethrough.
11. The valve for reverse cementing of claim 9, further comprising one or more centralizers to help prevent premature activation.
12. The valve for reverse cementing of claim 9, wherein the sliding sleeve and the nose are constructed of drillable material.
13. The valve for reverse cementing of claim 9, further comprising a latch mechanism.
14. The valve for reverse cementing of claim 13, wherein the latch mechanism comprises a pin and a groove.
15. The valve for reverse cementing of claim 13, wherein the latch mechanism is constructed such that it can be released without damage.
16. A method for reverse cementing, comprising:
    providing a valve comprising a sliding sleeve, an outer
    sleeve situated about at least a portion of the sliding
    sleeve and connected to a casing string;
    running the casing string and valve into a well bore while
    the valve is in a closed position;
    opening the valve after running the casing string by allowing
    the valve to contact the well bore;
    reverse cementing, while the valve is in an open position;
    and
    closing the valve after reverse cementing.
17. The method for reverse cementing of claim 16, further comprising:
    pumping a tracer fluid ahead of the cement.
18. The method for reverse cementing of claim 16, further comprising:
    allowing the cement to bond to the casing string.
19. The method for reverse cementing of claim 16, wherein
    the valve further comprises a latch mechanism and wherein
    closing the valve comprises applying pressure on the inside of
    the casing string.
20. The method for reverse cementing of claim 19, wherein
    closing the valve comprises removing weight from the casing string.

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