CIRCULATING COIL CLEANOUT TOOL AND METHOD

Inventor: Morley SEBREE, Lloydminster (CA)

Assignee: Morley SEBREE, Lone Rock (CA)

Appl. No.: 13/548,847

Filed: Jul. 13, 2012

Publication Classification

Int. Cl.
E21B 37/06 (2006.01)

U.S. Cl.
166/312, 166/70

The invention relates to a tool and method for cleaning a wellbore. The tool includes a tubing string comprising an upper end and a lower end, and defining a first bore for allowing passage of fluid from the wellbore to surface; a guide string disposed inside the tubing string and defining an internal bore to run coiled tubing therethrough, the coiled tubing carrying at least one jet nozzle; at least one seal disposed around the tubing string for sealing against a well casing; at least one port defined by the tubing string and positioned above the seal for allowing fluid to pass therethrough; and at least one valve positioned below the seal to allow fluid to pass upward through the valve but not downward.
CIRCULATING COIL CLEANOUT TOOL AND METHOD

FIELD OF THE INVENTION

[0001] This invention relates to a downhole cleaning tool and method for removing debris from a well.

BACKGROUND OF THE INVENTION

[0002] During production of oil from a well, debris such as sand, scale and particulates may clog the perforations at the bottom of the well, and accumulate with the production fluids within the wellbore. Such sand and debris can halt or hinder production, and damage well equipment by abrasion. It is thus important to be able to clean and remove such undesirable materials from the well as quickly and efficiently as possible.

[0003] The use of coiled tubing in wellbore cleanout technology is well-established. Conventional practices to remove debris include, for example, equipment such as concentric pipe, tubing operated pump-to-surface bailer and coiled tubing with jetting; engineering operations supported with hydraulic modeling such as high-rate circulation, forward or reverse circulation; and use of carrier fluids with suspension capabilities.

[0004] However, such approaches are often time-consuming, labour intensive, and costly. The required equipment is frequently mechanically complex which elevates the possibility of mechanical failure and costs for manufacture and repair.

[0005] Despite such advances, there remains a need for an effective method for the removal of debris from a well.

SUMMARY OF THE INVENTION

[0006] The present invention relates to a downhole cleaning tool and method for removing debris from a well.

[0007] In one aspect, the invention provides a downhole tool for cleaning a wellbore comprising:

[0008] a) a tubing string comprising an upper end and a lower end, and defining a first bore for allowing passage of fluid from the wellbore to surface;

[0009] b) a guide string disposed inside the tubing string and defining an internal bore to run coiled tubing therethrough, the coiled tubing carrying at least one jet nozzle;

[0010] c) at least one seal disposed around the tubing string for sealing against a well casing;

[0011] d) at least one port defined by the tubing string and positioned above the seal for allowing fluid to pass therethrough; and

[0012] e) at least one valve positioned below the seal to allow fluid to pass upward through the valve but not downward.

[0013] In one embodiment, the seal comprises at least one ring-shaped V cup having an interior diameter substantially equal to the outside diameter of the tubing string. In one embodiment, the seal comprises a pair of stacked V cups, an upper V cup being oriented upwardly and a lower V cup being oriented downwardly.

[0014] In one embodiment, the tubing string defines a pair of aligned, parallel spaced ports. In one embodiment, the valve comprises a ball valve. In one embodiment, the tubing string and guide string are threadless. In one embodiment, the guide string is sealed at its lower end. In one embodiment, a drain or a sliding sleeve is positioned between the seal and the valve. In one embodiment, the guide string and valve are optional components.

[0015] In another aspect, the invention provides a method of cleaning a wellbore using the above tool comprising the steps of:

[0016] a) running the tool into the wellbore in proximity to perforations;

[0017] b) pumping circulation fluid into an annulus defined between the tool and wellbore casing under sufficient pressure to force the circulation medium upwardly through the port into the tubing string to surface, wherein formation fluid and debris are suctioned upwardly into the tubing string;

[0018] c) running coiled tubing into the guide string to position the jet nozzle in proximity to the perforations;

[0019] d) pumping cleaning fluid into the coiled tubing to create a jet stream of fluid; and

[0020] e) continuously pumping the circulation medium and cleaning fluid for conveying formation fluid and debris upwardly from the wellbore to surface.

[0021] In one embodiment, the guide string and valve are omitted from the tool.

[0022] In one embodiment, the method further comprises running a profile nipple into the wellbore to land a blanking plug. In one embodiment, the method further comprises killing the wellbore and removing the tool from the killed wellbore. In one embodiment, kill fluid is pumped into the tubing string to blow a drain. In one embodiment, a sliding sleeve is actuated to allow fluid drainage.

[0023] Additional aspects and advantages of the present invention will be apparent in view of the description, which follows. It should be understood, however, that the detailed description and the specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The invention will now be described by way of an exemplary embodiment with reference to the accompanying simplified, diagrammatic, not-to-scale drawings. In the drawings:

[0025] FIG. 1A is a diagrammatic representation of an embodiment of the invention.

[0026] FIG. 1B is a diagrammatic representation of a transverse cross-sectional view taken along line 1A-1A of FIG. 1A.

[0027] FIG. 2 is a diagrammatic representation of an embodiment of the invention in an actuation position with a well.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0028] When describing the present invention, all terms not defined herein have their common art-recognized meanings. To the extent that the following description is of a specific embodiment or a particular use of the invention, it is intended to be illustrative only, and not limiting of the claimed invention. The following description is intended to cover all alter-
natives, modifications and equivalents that are included in the spirit and scope of the invention, as defined in the appended claims.

The present invention will now be described having reference to the accompanying figures. The invention provides a downhole cleaning tool and method for removing debris from a well with minimal hydrostatic pressure being placed on the formation. The tool and method enable injection of cleaning fluid through coiled tubing for lifting formation debris and debris from the wellbore. A suitable fluid is also circulated to provide enhanced lift for cleaning and removal.

A conventional gas well typically comprises a wellbore extending from the surface through the earth to intersect a production formation to produce natural gas, condensate (i.e., natural gas liquids such as propane and butane) and occasionally water. Similarly, an oil well typically varies from a few hundred to several thousand feet in depth. The tool may be placed in vertical, horizontal or inclined wellbores. "Horizontal" means a plane that is substantially parallel to the plane of the horizon. "Vertical" means a plane that is perpendicular to the horizontal plane. Such variations of well design are known to those skilled in the art.

The tool (1) is generally shown in the Figures to include a tubing string (10), a guide string (12), a pair of seals (14a, 14b), at least one port (16), and at least one valve (18). FIG. 2 shows the tool (1) mounted within the well tubular in a concentric orientation, for example, the production casing (32) of a conventional well to contact the wellbore fluid. As used herein, the term "concentric" refers to components sharing a common center and thus a substantially uniform annular dimension. However, one skilled in the art will recognize that two tubular members where one has a smaller diameter and is placed within the other may be considered concentric, even if they do not share the exact geometrical center, and even if they are not circular in cross-section.

The tubing string (10) comprises an upper end (20) which extends to the surface, and a lower end (22) which extends downhole. The tubing string (10) may generally be cylindrical and defines a first bore (24) which allows passage of circulation medium (indicated by arrow "a") from the annulus (34), and formation fluid and debris (indicated by arrow "b"), and a mixture of cleaning fluid, formation fluid and debris (also indicated by arrow "b") from the wellbore (42) to the surface.

The tool (1) provides convenient access for running coiled tubing (not shown) into the wellbore (42) by provision of the guide string (12). The guide string (12) is generally cylindrical and defines an internal bore (26) sized to accommodate the coiled tubing which is run therethrough during operation. The guide string (12) is disposed inside the tubing string (10) using suitable fastening means (28) as are known in the art.

In one embodiment, the guide string (12) may be sealed at its lower end (30). The sealing of the guide string (12) prevents the entry of formation fluid and debris into the guide string (12) from the wellbore (42) when the coiled tubing is not required.

Coiled tubing is typically inserted into a completed oil wellbore for various operations including, but not limited to, chemical injection, servicing, and transport of bottom hole assemblies. In one embodiment, a jet nozzle (not shown) is attached to the coiled tubing in a conventional manner.

At least one seal (14a, 14b) is disposed around the tubing string (10). The seal (14a, 14b) is sized so as to seal the tubing string (10) against the well casing (32). Suitable seals (14a, 14b) as are known in the art may be used. The seals (14a, 14b) may be formed of, for example, synthetic rubbers, thermoplastic materials, perfluoroelastomer materials, or other suitable substances known to those skilled in the art. Appropriate seals (14a, 14b) are sufficiently resilient for providing a good seal and sufficiently rigid for providing a relatively long life therefore. The dimensions of the seals (14a, 14b) are not essential to the invention and are dictated by the sizes of the tubing string (10) and well casing (32).

In one embodiment, the seal comprises an upper ring-shaped V cup (14a) and a lower ring-shaped V cup (14b). Each V cup (14a, 14b) has an interior diameter substantially equal to the outside diameter of the tubing string (10). The outer diameter of the V cup (14a, 14b) is substantially equal to the diameter of the well casing (32). Each V cup (14a, 14b) is a resiliently flexible disk shaped body having a central hole. The diameter of the central hole is substantially equal to the outer diameter of the tubing string (10) such that the V cup (14a, 14b) is placed around the tubing string (10) in a collar-like manner. The walls of the V cup (14a, 14b) extend radially from the central hole at an angle below the horizontal plane of the central hole such that the outer edge of the V cup (14a, 14b) terminates at a position below the plane of the central hole. The upper V cup (14a) and lower V cup (14b) are oriented in a stacked relationship. The upper V cup (14a) is oriented so that the cup walls extend radially upwards towards the surface. The lower V cup (14b) is oriented so that the cup walls extend radially downwards towards the downhole.

The tool (1) includes one or more ports (16). In one embodiment, the tubing string (10) defines a pair of aligned, parallel spaced ports (16). The ports (16) are positioned above the seals (14a, 14b) to allow entry of the circulation medium ("a") from the annulus (34) into the tubing string (10). The ports (16) provide an escape route above the upper V cup (14a) for the circulation medium ("a") which has been injected into the annulus (34).

The tubing string (10) includes at least one valve (18) positioned below the seals (14a, 14b). The valve (18) is one-way, allowing fluid to pass upward through the valve (18) but not downward. In one embodiment, the valve (18) comprises a ball valve. It will be understood by those skilled in the art that other suitable valves may be used, interchanged, or selected in accordance with the type of fluid being pumped; for example, a ball valve may be used with lighter fluids and in the absence of solid particulate material, while a hinged valve or a flapper valve may be used with heavy oil or sand.

The tool (1) can be constructed from any material or combination of materials having suitable properties such as, for example, mechanical strength, ability to withstand cold and adverse field conditions, corrosion resistance, and ease of machining.

The tool (1) may be manufactured as either an integral body or a composite tool. In one embodiment, the tubing string (10), guide string (12), ports (16), and valve (18) are combined in an integral body. As used herein, the term "integral" means that the body portion of the tubing string (10) is formed from a single cast or forged steel body which is machined to form the guide string (12), ports (16) and valve (18). With respect to the seals (14a, 14b), the body portion is sized and adapted to mount the seals (14a, 14b).
“threadless” means free of cooperating threads to interconnect components as they are aligned and rotated relative to one another. The use of a threadless tubing string (10) and guide string (12) minimizes friction and restriction of fluid flow within the annulus (34) during operation. The threadless configuration provides a reliable method for straight-pull emergency shear release. A shear is effectively built into the tubing string (10) to enable positive release of the tubing string (10) in the event that the tool (1) becomes stuck within the wellbore (42). A relatively large work string may also be used including one or more substantially large ports (16) for circulating fluids up the tubing string (10) and allowing more inflow with less restriction from the desired cleaning zone.

However, those skilled in the art will understand that various modifications can be made without altering the substance of the invention. For example, the tool (1) may be formed from the assembly of separate components which may be threadless.

In one embodiment, the guide string (12) and valve (18) are optionally omitted from the tool (1) in the event that the tubing string (10) may have an internal diameter which is insufficient to accommodate a guide string (12). In this configuration, the tubing string (10) is sized to accommodate coiled tubing which is appropriately sized to be easily run into or removed from the tubing string (10).

Use of the tool (1) will now be described having reference to FIG. 2. A suitable configuration for well control includes fluid injection inlets (36) having valves (38) which can be opened and closed to permit and cease the flow of fluid, and a blow-out preventer (40) which prevents the tool (1) from being blown out of the wellbore (42) when a blowout threatens. Positioning of the guide string (12) inside the tubing string (10) thus allows the blow-out preventer (40) to close around both the tubing string (10) and guide string (12) to prevent them from being blown out of the wellbore (42). In one embodiment, the blow-out preventer (40) comprises one or more variable bore-pipe rams which accommodate tubulars of varying diameters and through which the tubulars are tripped. Ported crossover bodies may be used for picking up work strings.

The tool (1) is run through the blowout preventer (40) into the wellbore (42) using conventional techniques and positioned in proximity to a plurality of perforations (44) which are diametrically opposed and spaced intermittently along the casing (32) adjacent an underground formation (46) to enable fluid communication with the formation (46). As used herein, the term “debris” means debris which generally exists in the formation (46) and in the casing (32), and results from operations including drilling or perforation debris, debris from cementing operations, and from mud solids. Naturally occurring debris such as sand, silts or clays may also be present in the formation (46).

The upper and lower V cups (14a, 14b) of the tool (1) are in a sealing engagement with the casing (32). Above the upper V cup (14a), an annulus (34) is defined between the tool (1) and casing (32). The tool valve (18) is in the closed position. The casing valves (38) are opened to allow pumping of circulation medium (“a”) under pressure through the inlets (36) into the annulus (34). The upper V cup (14a) acts as a physical barrier between the tool (1) and casing (32) to prevent the circulation medium (“a”) from flowing further downward through the annulus (34). Upon reaching the upper V cup (14a), the circulation medium (“a”) is forced upwardly through the ports (16) into the tubing string (10).

The circulation medium (“a”) which is pumped into the annulus (34) may comprise any suitable medium including, but are not limited to, drilling fluid, water-based fluids, foaming agents, and the like. In one embodiment, the circulation medium comprises low density foam. Foam inherently has a high viscosity at low shear rates making it extremely useful as a circulating medium. A variety of natural and process additives or polymers are known in the art to increase the lifting, carrying, and suspending capability of the circulation medium.

It is to be noted that the upper V cup (14a) prevents any hydrostatic pressure from being placed on the formation (46) since the vertical height of the circulation medium (“a”) is minimal above the perforations (44) when pumping or at rest. As used herein, the term “hydrostatic pressure” means the total fluid pressure created by the weight of a column of fluid, acting on any given point in a well.

The upwards motion of the circulation medium (“a”) into the tubing string (10) creates a Venturi effect and suctioning force which draws formation fluids and debris (“b”) from the formation (46) through the perforations (44). The upwards motion of the formation fluid and debris (“b”) opens the tool valve (18) to pass into the tubing string (10). The lower V cup (14b) acts as a physical barrier to prevent the formation fluid and debris (“b”) from flowing upwards into the annulus (34), and to force the formation fluid and debris (“b”) to flow upwards through the tool valve (18) into the tubing string (10) to be circulated to the surface.

Once circulation has been established, coiled tubing (not shown) is run into the guide string (12) using conventional coiled tubing techniques including, but not limited to, a kick off coil diverter. The guide string (12) facilitates insertion of the coiled tubing and access to the wellbore (42). Further, the guide string (12) provides stability and rigidity to the coiled tubing by preventing the coiled tubing from bending or wrapping around the tubing string (10). Agitation of sand around the coiled tubing is minimized. Further, the guide string (12) simply and effectively expedites the entry and removal of the coiled tubing from the wellbore (42) since the amount of drag is minimized.

The coiled tubing is positioned below the tool (1) in proximity to the perforations (44). Cleaning fluid is pumped under pressure through the coiled tubing and a bottom hole assembly (not shown). In one embodiment, the bottom hole assembly comprises a jet nozzle which emits a stream of pressurized fluid at a relatively high velocity. The pressurized fluid stream facilitates the clean out of the perforations (44), slots, and screens, and the suspension of the formation fluid and debris (“b”) within the cleaning fluid. As the circulation of circulation medium (“a”) continues, the suspension of cleaning fluid, formation fluid, and debris is drawn upwardly through the valve (18) into the tubing string (10). The suspension of cleaning fluid, formation fluid, and debris combines with the circulation medium (“a”) for conveyance to the surface. The clean out of the wellbore (42) is thus achieved by synchronizing the pumping of cleaning fluid through the coiled tubing with the continuous pumping of the circulation medium (“a”) into the annulus (34) to generate the desired downhole action.

The cleaning fluid (“b”) which is pumped through the coiled tubing may comprise any suitable fluid to clean different kinds of sand and scales, and to remove wax or asphaltene build-up. Suitable fluids may include, but are not
limited to, water- or oil-based fluids, water/brine, diesel/base oil, friction-reduced fluids, acids, surfactants, polymer gels, foaming agents, and the like.

Upon completion of the cleaning operation, the coiled tubing is withdrawn up through the guide string (12) for removal. A profile nipple (not shown) may be run into the wellbore (42) to land a blanking plug to prevent re-circulation of well fluids, thereby shutting in the well. The tubing string (10) and guide string (12) can be snubbed out.

It may be desirable to circulate kill fluid into the wellbore to stop the flow of the formation fluid. As used herein, the term “kill fluid” means any liquid pumped into a well to stop a kick (i.e., influx of formation fluid). The kill fluid is usually kill mud which is a weighted drilling mud. In one embodiment, the tubing string (10) may include a drain (not shown) positioned between the lower V cup (14b) and valve (18), and responsive to pressure. A kill fluid having sufficient density to overcome production of the formation fluid is pumped into the tubing string (10) to stop the flow and to blow the drain, resulting in draining of both the tubing string (10) and annulus (34) between the tool (1) and the casing (32) prior to tripping the tubulars out of the wellbore (42). In one embodiment, the tubing string (10) may include a sliding sleeve (not shown) positioned between the lower V cup (14b) and valve (18). As are known in the art, sliding sleeves include ports which can be opened or closed by a sliding component that is generally controlled and operated by a slickline tool string to allow the opening or closure of flow from a zone or communication from tubing to annulus. The sliding sleeve may be actuated to allow fluid drainage from the tubing string (10) and annulus (34). It will be recognized by those skilled in the art that any suitable sliding sleeve as are known in the art would be appropriate for use with the present invention. The draining operation avoids problems commonly associated with pulling wet strings. The tool (1) is then withdrawn up through the blowout preventer (40) for removal from the wellbore (42).

In one embodiment, the invention provides a method of cleaning a wellbore using the tool comprising running the tool into the wellbore in proximity to perforations; pumping circulation fluid into an annulus defined between the tool and well casing under sufficient pressure to force the circulation medium upwardly through the port into the tubing string, wherein formation fluid and debris are suctioned upwardly into the tubing string; running coiled tubing into the guide string to position the jet nozzle in proximity to the perforations; pumping cleaning fluid into the coiled tubing to create a jet stream of fluid; and continuously pumping the circulation medium and cleaning fluid for conveying formation fluid and debris up the wellbore to surface.

As will be apparent to those skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the scope of the invention claimed herein.

What is claimed is:

1. A downhole tool for cleaning a wellbore comprising:
   a) a tubing string comprising an upper end and a lower end, and defining a first bore for allowing passage of fluid from the wellbore to surface;
   b) a guide string disposed inside the tubing string and defining an internal bore to run coiled tubing therethrough, the coiled tubing carrying at least one jet nozzle;
   c) at least one seal disposed around the tubing string for sealing against a well casing;
   d) at least one port defined by the tubing string and positioned above the seal for allowing fluid to pass therethrough; and
   e) at least one valve positioned below the seal to allow fluid to pass upward through the valve but not downward.

2. The tool of claim 1, wherein the seal comprises at least one ring-shaped V cup having an interior diameter substantially equal to the outside diameter of the tubing string.

3. The tool of claim 2, wherein the seal comprises a pair of stacked V cups, an upper V cup being oriented upwardly and a lower V cup being oriented downwardly.

4. The tool of claim 1, wherein the tubing string defines a pair of aligned, parallel spaced ports.

5. The tool of claim 1, wherein the valve comprises a ball valve.

6. The tool of claim 1, wherein the tubing string and guide string are threadless.

7. The tool of claim 1, wherein the guide string is sealed at its lower end.

8. The tool of claim 1, comprising a drain or a sliding sleeve positioned between the seal and the valve.

9. The tool of claim 1, wherein the guide string and valve are optional components.

10. A method of cleaning a wellbore using the tool of claim 1 comprising the steps of:
   a) running the tool into the wellbore in proximity to perforations;
   b) pumping circulation fluid into an annulus defined between the tool and well casing under sufficient pressure to force the circulation medium upwardly through the port into the tubing string to surface, wherein formation fluid and debris are suctioned upwardly into the tubing string;
   c) running coiled tubing into the guide string to position the jet nozzle in proximity to the perforations;
   d) pumping cleaning fluid into the coiled tubing to create a jet stream of fluid; and
   e) continuously pumping the circulation medium and cleaning fluid for conveying formation fluid and debris upwardly from the wellbore to surface.

11. The method of claim 10, wherein the guide string and valve are omitted from the tool.

12. The method of claim 10, further comprising running a profile nipple into the wellbore to land a blanking plug.

13. The method of claim 10, further comprising killing the wellbore and removing the tool from the killed wellbore.

14. The method of claim 13, wherein kill fluid is pumped into the tubing string to blow a drain.

15. The method of claim 13, wherein a sliding sleeve is actuated to allow fluid drainage.

* * * * *